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SHIP OWNER'S DAY OF RECKONING—NOT YET.

Almost every year for the past fifteen years, since steel ships became a factor in the commerce of the great lakes, the cry has gone up: "We are building too many vessels. A day of reckoning is coming and woe be to the vessel owner." The alarm sounded when Mr. Rockefeller took a hand in the business a few years ago had hardly subsided before a great steel corporation acquired 112 of the choicest freighters, and then it was said in louder tones than ever that the days of the so-called individual vessel owners were certainly numbered, but they are here yet, owning probably half of the lake fleet, with a business outlook, if we go no further into the future than is reasonable, as good as it ever has been.

These thoughts are prompted by the fact that notwithstanding an increase of full 5,500,000 tons capacity in the lake fleet within the past two years, and about 3,000,000 tons more to be turned out from the ship yards before July next, it would not be surprising to find steel manufacturers ready to make freight contracts with the ship owners for 1902 before the present season is altogether at an end, or at least very early in the winter. Local conditions, mainly the inability of the railroads to take freight from the ships fast enough to keep them continually employed, have no doubt had much to do with the high rates during the present season, but after all it would seem that while surplus ship capacity is so much talked of, not enough consideration is given to enormous increase in freight moved over the lake region—not in one year compared with another but for a period of years. Take, for instance, the two items shown in the accompanying table—output of iron ore from the Lake Superior region during twenty years past and the movement of freight of all kinds to and from Lake Superior during the same period. It will be

Year.	Ore production, Lake Superior region.	Movement of freight to and from Lake Superior.
1881	2,319,469	1,567,741
1882	2,965,412	2,029,521
1883	2,352,840	2,267,105
1884	2,518,693	2,874,557
1885	2,466,642	3,256,628
1886	3,565,144	4,527,759
1887	4,762,107	5,494,649
1888	5,063,877	6,411,423
1889	7,292,643	7,516,022
1890	9,003,725	9,041,213
1891	7,071,053	8,888,759
1892	9,072,241	11,214 333
1893	6,065,716	10,796,572
1894	7,748,312	13,195,850
1895	10,429,073	15,062,580
1896	9,934,828	16,239,061
1897	12,464,574	18,982,755
1898	14,024,673	21,234,664
1899	18,251,804	25,255,810
1900	19,059,393	25,643,073
1901	*20,500,000	*30,000,000

*Estimated.

noted by reference to the column showing Lake Superior movement of freight that the total in round numbers was only 1,500,000 tons in 1881, compared with 8,900,000 tons in 1891 and 30,000,000 tons in 1901. The ore movement shows increases almost equally amazing. And if we turn to a few ready figures regarding the iron and steel industry we find that there will be produced in the United States in 1901 more than 15,500,000 tons of pig iron, against 1,868,961 tons in 1876, and that we are now making pig iron at the rate of 16,700,000 tons a year, or on a basis of 5,500,000 tons more than at this time a year ago.

Thus it may be said that although the day of reckoning will come some time for the ship owner, he feels quite secure as regards at least another year. He is expecting that profitable rates in contracts for 1902 will be offered him before he has fairly settled up business of the present year.

Common stock of the American Ship Building Co. (consolidated lake yards), which had been selling at about $35 a share, has advanced within the past few days to $38 and there is considerable activity in it. With orders in hand for some thirty-one ships to come out next year, and with prospects of a surplus running into three or four millions above preferred dividends when the company's year is at an end, a dividend on the common stock is again looked for, and this is the cause of the advance. It is rumored that a common stock dividend to be paid in April will be declared in January.

J. C. Gilchrist of Cleveland, who seems to be reaching for the hundred mark in a fleet of lake ships, is naming some of his latest steel steamers for leading associates in the several steamship companies that he controls. A big steel freighter, launched at Lorain a few days ago, was named for Frank W. Osborne, president of the Pittsburg Coal Co., and a duplicate vessel to be launched a few weeks hence will be named for Frank W. Hart, who is at the head of one of the large wholesale millinery houses of Cleveland.

One great organization among the railways—the Pennsylvania company—will do its share towards relieving the freight congestion that has existed for several months past. This great company has placed contracts in all for 19,000 cars, most of them steel and 12,000 of them of the 40 to 55-ton kind used in the coal and iron industry. They have forty locomotives under order, in addition to those building in their own shops, and have set aside $6,000,000 for new tracks, double tracking, etc.

NEW SHIP BUILDING ENTERPRISES.

The ship yard at Perth Amboy, N. J., owned by the estate of Hugh Ramsey, which has been idle for some time past, has been taken in hand by the Standard Ship Building Co., a new organization. Officials of the new company announce that they are already in position to undertake the construction and repair of steel and wooden vessels of every description, steam, gasoline and kerosene engines, marine and land boilers, water-tube and cylindrical. The capacity of the yard is sufficient for building vessels up to 450 ft. in length. The president and manager of the company is C. O. Liljegren. W. E. Ramsey is vice-president, A. H. Crowell, secretary and treasurer, and M. A. Edgar, Adrian Lyon, C. F. Hall, A. L. Ramsey and C. Lee Straub, directors. The president was last year designer for the New York Ship Building Co. at Camden, N. J. Before that he was employed by the Herreshoffs of Bristol, R. I., and by the Newport News Ship Building & Dry Dock Co.

A project contemplating the establishment of a ship building plant on the Gulf coast is in the hands of New York and southern capitalists. The company, to be known as the Gulf Coast Ship Building & Dry Dock Co., has been incorporated under the laws of Alabama. It is proposed to construct and operate a modern ship building and marine railway plant on the Bay of Mobile and a dry dock and ship repairing plant at the port of New Orleans. An option has been obtained upon about 2,000 acres of land on the Bay of Mobile, with a frontage of over a mile. The company has been capitalized at $5,000,000, and contemplates an issue of $4,000,000 of first mortgage thirty-five-year 5 per cent. sinking fund bonds to cover the cost of the acquisition, construction and initial equipment of the two plants. These directors have been chosen thus far: Charles W. Jesup, S. B. McConnico and Cassius M. Wicker of New York; Alfred S. Elliott of Wilmington, Del.; Robert C. Morris and Lewis Johnson of New Orleans, and Patrick J. Lyons and E. L. Russell of Mobile. The officers are: President, Charles M. Jesup; vice-president, Cassius M. Wicker; second vice-president and secretary, S. B. McConnico; third vice-president and treasurer, Robert C. Morris. The Finance Realty Trust Co. of New York will try to finance the new corporation.

ORDERS FOR REORGANIZED BALTIMORE COMPANY.

Baltimore, Md., Nov. 20.—It is rumored that the recently reorganized Columbian Iron Works of Baltimore, Md., under entirely new ownership and management, with the name Baltimore Dry Dock Co., is to build a fast bay steamer 187 ft. long between perpendiculars, 12 ft. 3 in. molded depth and 7 ft. 6 in. draught. This steamer is to be single-screw driven by triple-expansion engines of modern type. The boilers are to be two in number, double enders, 9 ft. in diameter by 21 ft. long. The displacement is stated at 600 tons, and the steamer will carry about 1,200 passengers and 100 tons of freight. A speed of 16 knots is expected, which will make the boat one of the fastest ever built in Baltimore.

The first contract to be published by the Baltimore Dry Dock Co. since its organization is with Messrs. Sinn & Page, naval architects and marine engineers of Sparrow's Point, Md., on account of the Woodsum Steamboat Co. of Concord, N. H., for a steel passenger and package freight steamer 55 ft. long, 12 ft. beam and 5 ft. 1½ in. molded depth. This steamer was designed by Messrs. Sinn & Page for service on Lake Sunapee, N. H., and will be a handsome addition to the present fleet of the Woodsum Steamboat Co. The specifications state that the crew of the steamer will be limited to two men, and that the machinery must therefore be as nearly automatic in its operation as possible. Special fittings and handling gear are specified to obtain this result. The boat will be built complete by the Baltimore Dry Dock Co. and delivered in four months, knocked down, and shipped to Lake Sunapee, where it will be re-erected by the contractors, Messrs. Sinn & Page, and delivered to the owners on or before June 9, 1902, after a satisfactory trial trip.

STEEL PLATE COMBINATION.

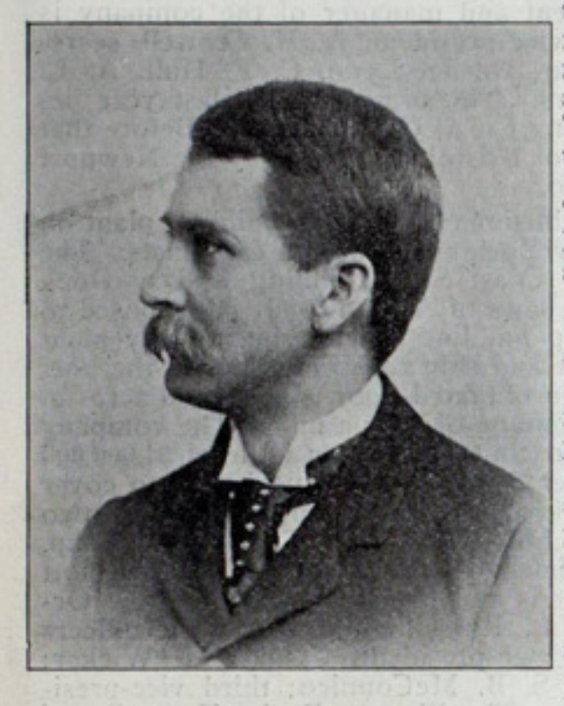
A combination of steel plate manufacturers has been effected without Jones & Laughlins' of Pittsburg and with a capital of about $25,000,000 as against about $50,000,000 as at first proposed. Concerns that have signed agreements of sale are: Lukens Iron Works, Coatsville; Tidewater Steel Co., Chester; Central Steel Co. of Harrisburg and Worth Bros. This will make quite a formidable combination, especially if operated in harmony with the United States Steel Corporation, and it has all along been understood that President Schwab is the moving spirit in the negotiations. Jones & Laughlins and the Carbon Steel Co. of Pittsburg, with the Otis company of Cleveland, will still be independent manufacturers and will undoubtedly get a very large share of western business, but the combination will operate to decided advantage in the east. It is well known, of course, that the plate manufacturers have for some time past been working under agreements but they have differed as to allotments and as in all other combinations of the "gentlemen's agreement" kind, harmony would probably disappear in times of dull business. This is why Charles M. Schwab desired an organization that could be depended upon when working with the Steel Corporation in the matter of prices. It is said that Charles T. Schoen, the founder of the Pressed Steel Car Co., and until his recent retirement the leading spirit in it, will be asked to take the presidency of the new company. Mr. Schoen has for years been a close personal and business friend of Mr. Schwab.

The combination means fixed prices for ship and boiler plate in the east and probably a more steady market also in the lake region. It is also more than probable that the plants above referred to will at some future date be taken over by the steel corporation.

NAVAL ARCHITECTS—MARINE ENGINEERS.

A MEMORABLE MEETING OF THIS DISTINGUISHED SOCIETY HAS JUST BEEN CLOSED IN NEW YORK—IT REFLECTS THE GROWING MARITIME IMPORTANCE OF THE NATION—MEMBERSHIP OVER 800.

Undoubtedly the best evidence of the growing maritime importance of the nation is to be found in the constant and healthful growth of the Society of Naval Architects and Marine Engineers, whose ninth annual meeting was held in New York on Thursday and Friday last, the 14th and 15th. Ever since it was organized this society has added to its membership at the rate of about 100 per annum. This year 105 new names were enrolled in the following order: Members, twenty-seven; associates, fifty-six; juniors, twenty-two. This gives the society a total membership at the present time of 860. The membership numbered 755 at the opening session of Thursday morning, the new appointments being duly made by the council. The report of the secretary-treasurer, Washington L. Capps, revealed the fact that the society has resources amounting to $15,462.64, against which there is no liability. The sessions were, as usual, held in the auditorium of the Mechanical Engineers' building, No. 12 West Thirty-first street, a courtesy which has invariably been extended to the society by the Mechanical Engineers.



NAVAL CONSTRUCTOR D. W. TAYLOR.

Secretary-Treasurer Washington L. Capps stated that in the absence of the president of the society, Mr. Clement A. Griscom of Philadelphia, it would be necessary to elect a temporary chairman. Upon motion of Mr. E. Platt Stratton, Mr. Stevenson Taylor was unanimously elected to this office. His impromptu address was most felicitous and happy. He said:

"On account of the unavoidable absence abroad of our president, you will be deprived of the pleasure of having his annual address, but the society has been briefly informed of its present condition through the report of the secretary-treasurer. While the society has made very large gains in membership, as is shown by the report of the secretary-treasurer, it has had the misfortune to lose by death some of its most distinguished members, among them being one of its vice-presidents, the late Rear Admiral Bunce. Through the liberality of a member of the council a prize was offered for the best paper on the 'Theoretical and Practical Methods of Balancing Marine Engines.' A committee of the council, composed of Messrs. J. E. Denton, Stevenson Taylor and Lewis Nixon, was appointed to examine the papers submitted in competition and recommend the paper entitled to the prize. Two of the papers submitted were of such surpassing excellence that the committee unanimously recommended to the council that the paper which did not win the original prize be awarded a special prize donated by the society. The committee's recommendations met with the unanimous approval of the council, which has awarded a special prize of $50 to the paper entitled 'Let Truth be Our Guide,' the first prize being awarded to the paper having as its motto 'Labor Omnia Vincet.' The society is to be congratulated in having presented to it papers of such universal merit as the ones to which prizes have been awarded and the council unanimously decided that the executive committee be given authority to offer prizes during the next year, the subject to be selected by the executive committee and the amount of the prize or prizes to be limited to $200. The meeting is now open for the reading and discussion of papers."

It is probably unnecessary to note that the committee when it made its decision was unaware of the authorship of the papers. When it was subsequently announced that the author of the prize winning paper, "Labor Omnia Vincet," was Naval Constructor D. W. Taylor, and that of the paper "Let Truth be Our Guide," to which a special prize was given, was Rear Admiral George Wallace Melville, chief of the bureau of steam engineering, the applause was general. These papers were indisputably the feature of the meetings.

All of the officers of the past year were re-elected. Rear Admiral T. Bowles, chief constructor of the navy, was added to the list of vice-presidents in place of Rear Admiral Bunce, deceased. Mr. H. Taylor Gause resigned from the council, which with the elevation of Rear Admiral Bowles, left two vacancies in that body. These were filled by the appointments of Naval Constructor D. W. Taylor and Mr. Ira M. Hollis, professor of engineering at Harvard University, so that the list of officers is as follows:

LIST OF OFFICERS FOR ENSUING YEAR.

President, Clement A. Griscom.

Vice-presidents—Charles H. Cramp, Philip Hichborn, Charles H. Loring, George W. Melville, George W. Quintard, Irving M. Scott, Frank L. Fernald, Francis T. Bowles, William T. Sampson and Edwin A. Stevens.

Members and associate members of the council—William F. Durand, French E. Chadwick, Nathaniel G. Herreshoff, William H. Jacques, John C. Kafer, Frank B. King, Frank E. Kirby, Jacob W. Miller, Washington L. Capps, Edward Farmer, Lewis Nixon, Harrington Putnam, W. I. Babcock, Horace See, E. Platt Stratton, Stevenson Taylor, George E. Weed, James E. Denton, Walter M. McFarland, George W. Dickie, Cecil H. Peabody, D. W. Taylor and Ira M. Hollis.

Executive Committee—Francis T. Bowles, Stevenson Taylor, Harrington Putnam, Lewis Nixon, Edwin A. Stevens, Clement A. Griscom and Washington L. Capps, ex-officio.

Secretary and Treasurer—Washington L. Capps, U. S. N., 12 West Thirty-first street, New York.

At the instigation of Rear Admiral Bowles, chief constructor of the navy, the following resolution was adopted:

"Resolved, that the council be requested to revise the constitution with view of increasing the revenue of the society by increase of dues and entrance fees and also to secure by revision such change in the method of election of officers and other matters which may appear to be for the advancement of the society; such revision when made to be submitted for the consideration and vote of each member and associate; the result of such vote to be submitted at the next council meeting for action with the recommendation of the council."

In explanation of this resolution Admiral Bowles said that the society was now in its tenth year and that for the first time in its existence its expenses were more than the receipts. He added also that the executive work of the society had been done by a few unselfish and devoted souls, who, while no less devoted now, had assumed other duties with their increasing years and did not have the time to devote to the society. He recommended that a permanent professional secretary be employed.

LIST OF MEMBERS IN ATTENDANCE.

The list of members and others in attendance at the several sessions for the reading of papers and at the banquet included the following:

D. Almy, George H. Barriss, Capt. Wright, Rear Admiral P. C. Asserson, L. Katzenstein, Horace See, Col. Petroff, Chief Engineer Marzkevitch, Assistant Naval Constructor J. W. Powell, Assistant Naval Constructor Williams, George N. Gardiner, Warren E. Hill, William A. Dakson, Prof. C. C. Thomas, F. Merriam Wheeler, Fred A. Humewell, D. G. Moore, Theodore Lucas, Albert Leitch, William R. C. Wood, Parker H. Kemble, Lieut. L. H. Chandler, Capt. H. S. Ross, Prof. James E. Denton, O. B. Keller, Charles D. Mosher, Mark Forgusson, P. J. Donnelly, John S. Hyde, J. C. McGuire, Prof. A. J. MacLean, W. D. Forbes, Capt. H. S. Ross, Naval Constructor J. H. Linnard, Prof. C. H. Peabody, Capt. J. M. Miller, Prof. William F. Durand, Andrew Fletcher, Andrew Fletcher, Jr., F. M. Leavitt, H. M. Jock, B. F. O'Connor, W. M. McFarland, Stevenson Taylor, J. C. Kafer, W. I. Babcock, Naval Constructor D. W. Taylor, Naval Constructor Robert Strocker, Capt. Von Rebeur Paschwitz of the German navy, Miers Coryell, E. Platt Stratton, Naval Constructor Washington L. Capps, Assistant Naval Constructor W. G. Groesbeck, Assistant Naval Constructor Robert C. P. Wetherbee, Commodore de Faramond of the French navy, F. B. King, Rear Admiral John Lowe, Chief Engineer Ayres, Chief Engineer Magee, F. L. Du Bosque, Sinclair Stuart, Naval Constructor Lawrence Spear, William H. Deming, Charles B. Rowland, Thomas F. Rowland, Jr., Charles H. Cramp, C. S. Smith, Nicholas Cushing, F. P. Palen, E. B. Shock, L. E. Eckart, H. E. Grieshaber, S. S. Jordan, W. P. Stephens, Mason S. Chase, Rear Admiral F. T. Bowles, James Young, Prof. A. H. Sabin, J. Brauckle, Prof. D. Jacobus, Lieut. A. P. Niblock, Donald Stuart, William F. Palmer, James Swan, P. Leventhal, Carl T. Holmes, Col. E. A. Stevens, Harvey D. Goulder, George L. Norton, Frederick Hepburn, Capt. B. F. Wood, Naval Constructor William L. Mintonye, George H. Waters, George Crouse Cook, John Loyd, H. A. Magoun, Joseph Barre, William Gardner, Charles H. Buckeley, J. A. Horgan, William Rowland, W. H. Fletcher, W. H. Bailey, Naval Constructor Lloyd Bankson, Naval Constructor John Hanscom, H. E. Bancker, John Nolan, F. P. Lewis, J. R. Andrews, H. P. Elwell, F. O. Wellington, John Fritz, F. C. Whitehouse, A. A. Thresher, J. W. Kellogg, Charles Wood, Oberlin Smith, R. Hummel, H. Thomas, L. H. McMirtrie, H. C. Guile, John Platt and A. P. Robinson.

NEW MEMBERS, ASSOCIATES AND JUNIORS.

The list of new members, associates and juniors, and the advancement in membership are as follows:

Members—Roland Allwork, inspecting engineer, Panama line, 24 State street, New York; John Millington Blankenship, assistant superintendent Merchants and Miners Transportation Co., Baltimore; Jacob Brauchli, inspecting draughtsman, office of superintending engineer, United States navy, Newport News, Va.; William L. Cathcart, adjunct professor, mechanical engineering, Columbia university, New York; William B. Collison, first-class draughtsman, navy yard, New York; B. B. Crowninshield, naval architect, 31 State street, Boston; R. E. Hall, secretary, New York Steam Fitting Co., 137 Elm street, New York; Urban Harvey, second assistant engineer, revenue cutter service, Washington, D. C.; V. L. Legarda, naval architect, Union Iron Works, San Francisco; W. S. Leland, instructor in naval architecture, Massachusetts Institute Technology, Boston; Philip Leventhal, designing engineer and chief draughtsman, Gardner & Cox, 1 Broadway, New York; P. H. McGiehan, draughtsman, navy yard, New York; S. H. Moore, United States local inspector of boilers, 2 River st., Chicago; J. B. Rowen, in charge of mold loft, Wm. Cramp & Sons' ship yard, Philadelphia; Yasnichi Sugitani, ship yard manager, Mitsu Bishi Dock Yards & Engine Works, Nagasaki, Japan; P. A. Talbot, chief hull draughtsman, Wm. R. Trigg Co., Richmond; Frank Van Vleck, assistant superintendent engineer, United States army transport service, 36 New Montgomery street, San Francisco; Harry Wheeler, superintendent, Atlas Steamship Co., Pier 44, North river, New York; Nagakato Yamamoto, chief draughtsman, Mitsu Bishi Dock Yards & Engine Works, Nagasaki, Japan; S. S. Caskey, Harlan & Hollingsworth Co., Wilmington, Del.; Samuel D. B. Brown,

REAR-ADMIRAL GEO. W. MELVILLE.

William R. Trigg Co., Richmond; Robert H. Fraser, engineer surveyor, American Record; Ernest A. Perkins, Fore River Ship & Engine Co., Quincy, Mass.; C. C. Bauers, Howard C. Higgins, George H. Bull and Henry R. Curwen.

Advanced from associate to member—Wm. C. Groesbeck, assistant naval constructor, U. S. N., Wm. R. Trigg Co., Richmond; Joseph Ezekiel McDonald, assistant naval constructor, U. S. N., navy yard, Mare Island, Cal.; Henry H. Schulze, leading draughtsman, in charge of merchant work, Wm. R. Trigg Co., Richmond; Arthur Allen, designing draughtsman, Moran Bros. Co., Seattle, Wash.; George Crouse Cook, naval architect and engineer, New York; William Carr Nickerson, draughtsman, William Cramp & Sons Ship & Engine Building Co., Philadelphia.

Associates—H. L. Aldrich, publisher and manager of Marine Engineering, 309 Broadway, New York; E. I. G. Andrisen, assistant manager to Holzapfel's Composition Co., 18 Broadway, New York; George H. Bates, chief engineer, Burlee Dry Dock Co., Port Richmond, S. I., Box 40 Crawford, N. J.; Guy A. Bissett, assistant naval constructor, U. S. N., navy yard, Boston, Mass.; H. B. Bloomsburg, draughtsman, engine department, Newport News company, Newport News, Va.; W. W. Clark, engine draughtsman, Neafie & Levy company, Philadelphia; Alexis Crane, New York manager and special expert in ship equipment for Art Metal Construction Co., 346 Broadway, New York; Frank H. Cross, hull draughtsman, Wm. R. Trigg Co., Richmond; Karl E. Delin draughtsman, Newport News company, Newport News, Va.; Thomas M. Dick, ensign, U. S. N. (retired), professor of mechanical engineering, A. & M. College, Raleigh, N. C.; Edmund B. Edwards, draughtsman, Fore River Ship & Engine Co., Quincy, Mass.; Harvey D. Goulder, proctor in admiralty, Cleveland; James R. Guy, B. S., hull draughtsman, Wm. R. Trigg Co., Richmond; O. P. Hagstrom, leading draughtsman, Newport News company, Newport News, Va.; Bernard Hedstrom, hull draughtsman, Moran Bros. Co., Seattle, Wash.; Gabriel Hofgaard, ship draughtsman, Wm. Cramp & Sons' company, Philadelphia; Charles H. Hughes, in charge of torpedo boats under construction, Crescent Ship Yard, Elizabeth, N. J.; Philip Lamson, draughtsman, hull department, Newport News company, Newport News, Va.; Frank Provost Larkin, draughtsman, engineering department, Newport News company; Newport News, Va.; Newbury D. Lawton, 40 Wall street, New York; Curtis D. Mabry, hull and calculating draughtsman, Gardner & Cox, 1 Broadway, New York; Lewis A. Mason, chief hull draughtsman, Burlee Dry Dock Co., Port Richmond, S. I., New York; Joseph McCreery, Joseph McCreery & Sons., Toledo, O.; Wm. C. McGowan, assistant draughtsman, Wm. R. Trigg Co., Richmond; Charles C. Moss, ship draughtsman, Wm. R. Trigg Co., Richmond; L. D. Norsworthy, ship draughtsman, Bath Iron Works, Bath, Me.; Charles T. Perkins, draughtsman, navy yard, Portsmouth, N. H.; H. B. Stilz, ship draughtsman, naval constructor's office, Bath Iron Works, Bath, Me.; H. H. Thayer, Jr., estimating draughtsman, Harlan & Hollingsworth Co., Wilmington, Del.; H. M. Toch, manufacturer of marine cements and ship bottom paints, 472 West Broadway, New York; Wm. R. Trigg, president Wm. R. Trigg Co., Richmond; Charles J. Weinz, superintendent insulating construction, H. W. Johns Mfg. Co., 100 William street, New York; C. C. West, draughtsman, hull department, Chicago Ship Building Co., Chicago; C. G. Whiton, treasurer and agent, New Bedford, Martha's Vineyard & Nantucket Steamboat Co., 7 Commercial street, New Bedford, Mass; Charles F. Willard, scientific department, Eastern Ship Building Co., New London, Conn.; Henry Williams, assistant naval constructor, navy yard, New York; Oscar F. Witt, hull draughtsman, Newport News company, Newport News, Va.; Robert K. Wright, master of steam yacht Nourmahal, New York Yacht Club, Forty-fourth street, New York; John P. Chase, draughtsman Fore River Ship & Engine Co., Quincy, Mass.; Edson B. Schock, superintendent construction, Holland Submarine Torpedo Boat Co.; Lieut. L. H. Chandler, United States navy; Walter H. Rogers, leading draughtsman Wm. Cramp & Sons' Ship & Engine Building Co., Philadelphia; Walter H. Millard, Holland Submarine Torpedo Boat Co.; William E. Jackson, Watson C. Schreiner, Howard H. Hummel, Alfred W. Minuse, John F. Bruton, Fred P. Hall, Jacob Katzenstein, Thomas A. Watson, Frederic Hepburn, James G. Lindsay, Axel E. Petre, William I. Wyman and C. E. Houston.

Transfer from junior membership to member—Thomas M. Cornbrooks, ship draughtsman, hull department, Maryland Steel Co., Sparrow's Point, Md.; Alpheus Appleton Packard, in charge of ordering department, New York Ship Building Co., Camden, N. J.; Edwin S. Alexander, inspector Newport News Ship Building & Dry Dock Co.; E. J. Cornbrooks, Maryland Steel Co.

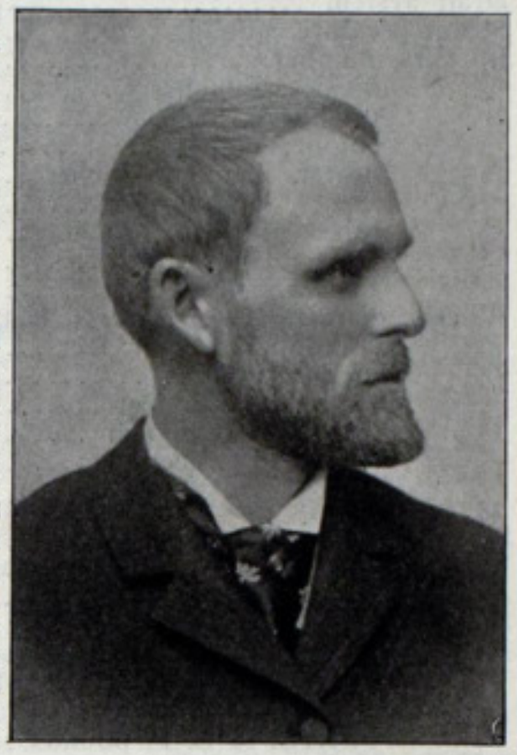
Juniors—H. D. Bacon, draughtsman, hull department, New York Ship Building Co., Camden, N. J.; Alex. de Bretteville, draughtsman, Fulton Engineering & Ship Building Works, San Francisco; James A. Crawford, assistant draughtsman, naval constructor's office, Union Iron Works, San Francisco; Hugh Dougherty, navy yard, New York; Charles H. Godbold, Jr., draughtsman, U. S. N., Union Iron Works, San Francisco; Francis G. Hall, Jr., assistant manager, Naval Electric Co., 95 Liberty street, New York; John G. Kreer, engineer, with Purdy & Henderson, 539 La Salle street, Chicago; George Barrell Moody, government draughtsman, Bath Iron Works, Bath, Me.; Walter A. Read, assistant draughtsman, navy yard, New York; Arthur L. Terry, Jr., draughtsman, hull department, New York Ship Building Co., Camden, N. J.; Roger W. Wright, assistant draughtsman, United States inspector of machinery, Bath Iron Works, Bath, Me.; H. H. Grogan, assistant draughtsman, United States navy; Charles A. North, Herbert H. Christophersen, Samuel D. McComb, Robert S. Haight, M. E. Davis, W. B. Caswell, William F. Hussey, Edwin E. Mager and Charles C. Brush.

THE READING OF PAPERS.

FIRST ON THE PROGRAM WAS MR. FRANK E. KIRBY'S ACCOUNT OF THE CITY OF ERIE-TASHMOO RACE—IT IS ATTENDED BY SPIRITED DISCUSSION—THE PRIZE PAPERS AND OTHERS.

Before the first paper was read it was announced that discussion would be welcome and was, in fact, the chief object of the reading. Each speaker was allowed a single period of ten minutes and rejoinders were in order only by the writers of the papers. The first paper on the program was "The Trial of Speed Between the Steamers City of Erie and Tashmoo," by Mr. Frank E. Kirby of Detroit. Considerable regret was expressed that Mr. Kirby could not be present himself to read the paper, but he found a most sympathetic interpreter in Mr. Stevenson Taylor. While the subject matter of this paper has been thoroughly gone over in the Review it will be set forth again at length owing to its interest and the discussion which it provoked. Accompanying Mr. Kirby's paper were photographs of the vessels, with drawings showing lines of both steamers, draught of water and trim on date of trial.

"On June 4, 1901, a trial of speed took place on Lake Erie between the paddle steamers City of Erie and Tashmoo. The course was straight along the south shore of the lake, starting from a line off the waterworks crib six miles outside of the breakwater at Cleveland, to a line ten miles off Presq'ile lighthouse at Erie, Pa. The distance measured on the United States coast survey chart, which is on a scale 1/400,000, is 94 statute miles. Computed from the latitude and longitude of the lighthouses at Cleveland and Erie, and corrected for location of starting line, the distance is 94.31 miles. Measured on the chart issued by the hydrographic office of the navy department, the distance is 95.25 miles. The calculations in this paper are based on a distance of 94 miles. The nearest land to the course was at Fairport, 2½ miles distant. The average depth of water along the course was 61.31 ft.; minimum depth, 35 ft.; maximum depth, 77 ft. Weather fine; sea smooth.



MR. FRANK E. KIRBY.

"The City of Erie is a passenger and deck-freight steamer, owned and operated by the Cleveland & Buffalo Transit Co. of Cleveland and is in daily service with the steamer City of Buffalo between the ports of Cleveland and Buffalo. Distance between harbor entrances, 173 miles; running time, 10 hours. Best service run, 8 hours, 32 minutes. The hull is built of mild steel, divided into ten compartments, by nine bulkheads, six of which are watertight. The upper decks and houses are of wood, arranged in the usual style of American steamboats. Number of staterooms, 163; number of regular passengers allowed by permit, 600; excursion permit, 2,700. This could be increased by providing additional equipment. Number of officers and crew, 108. Capacity for freight, 600 tons. Engine, single, compound beam, driving feathering paddle-wheels. Boilers, six cylindrical, return tubular. Pressure of steam, 130 lbs. Amount of coal used per round trip in 48 hours, 67½ tons; amount of coal used per round trip of 24 hours, 55 tons. Coal used on the run of June 4 was select bituminous lump from the Youghiogheny district of the Pittsburg Coal Co.

"The Tashmoo is an exclusively passenger steamer, owned and operated by the White Star line of Detroit; in daily service on Detroit and St. Clair rivers, crossing Lake St. Clair. The round trip between Detroit and Port Huron occupies 11½ hours; twenty landings are made each way, and lying at Port Huron two hours. Most of the run is in shallow water, which includes the St. Clair ship-canal and the narrow cuts in Lake St. Clair. She has three complete decks for passengers; ten parlors, cafe and buffet on main deck; smoking-room on upper deck. Number of passengers allowed by permit, 3,000; number of officers and crew, 84. Engines, inclined, triple-expansion, driving feathering paddle-wheels. Boilers, cylindrical, return tubular—two double-ended and three single-ended. Steam pressure, 175 lbs. Consumption of coal per day, 27 tons. Coal used when running with City of Erie was bituminous, from the Jackson Hill mine, Jackson county, Ohio. While the usual service of the Tashmoo is in smooth water, she is designed, built and classed as a lake steamer, making occasional runs across the head of Lake Erie to Toledo, the southern terminus of the White Star line. She has a heavy equipment of anchors, chains, and eight large life boats. She has a peculiar cross-section designed to allow the boilers to go under deck, thus leaving the main deck clear for passengers. The thin ends of the hull were cut off to reduce the weight, and allow turning a reverse curve of 180° in narrow waters at two landing places on her regular route. The only novel feature in her design is the gear for handling the water ballast used for trimming athwartship. Tanks are built on the guards, just forward of the wheel housings, having a capacity when full of 13 tons of water each. Time required to fill one tank, 7 minutes, the discharge water from the air pump being used. Time required to discharge, 45 seconds. The valves are arranged so that, in any position, there is always a full outlet from the air pump. A connection is fitted for filling the tanks by the fire pump when main engine is not in motion. One man easily handles the gear, and his services are only occasionally required, except at landings. Particulars of the steamers and data of the speed trial on June 4, as follows:

	City of Erie.	Tashmoo.
Length over all, feet	324	308
Length on keel, feet	314	300
Beam, feet	44	37.5
Breadth over guards, feet	77.2	69
Depth, feet	18	13.5
Draught, forward, feet	9.75	8.12
Draught, aft, feet	10.83	8.46
Draught, mean, feet	10.29	8.29
Displacement, tons	2,233	1,224
Trial load, tons	250	60
Wetted surface, square feet	12,776	8,976
Prismatic coefficient	.603	.584
Engine, type	Compound, beam.	Triple, inclined.

	City of Erie.	Tashmoo.
Cylinder, H.P. diameter, inches	52	33
I.P. diameter, inches	—	51
L.P. diameter, inches	80	82
stroke, inches H.P.	96	72
L.P.	144	—
Air Pump, diameter, inches	52	45
stroke, inches	45	24
Feed pump, independent	16x11x14	14x8x12
Fire pump	14x8x10	10x6x10
Boilers, cylindrical, number	6	5
diameter, feet	12.5	11.08
length, feet	11.75	3 of 11.33 2 of 22
furnaces, diameter, inches	46	42
grate length, feet	5.5	6
surface, square feet	252	294
heating surface, square feet	11,580	8,750
Draft system	Howdens.	Natural.
Steam pressure, pounds	130	175
Blowers, number	2	—
diameter, inches	66	—
discharge, inches	34x34	—
engine, inches	7x7	—
heater, diameter, inches	25	25
length, feet	10.17	9.5
tubes, diameter, inches	1½	1½
length, feet	8	7
surface, square feet	302	282
Wheels, diameter over buckets, feet	28.5	22.42
Polygon, diameter, feet	25.17	19.08
buckets, number	11	9
width, feet	4	3.75
length, feet	12	12
dip, feet	5.17	4.75
DATA OF THE RUN.		
Steam pressure, pounds	120.4	175*
Vacuum, inches	23.5	22
Air pressure, inches	5 max.	—
Revolutions per minute	33.25	40.08
M. E. P. in H. P. cylinder, pounds	58.4	—
I. P. cylinder, pounds	—	—
L. P. cylinder, pounds	36.6	—
referred to L. P. pounds	53.07	—
I. H. P., H. P. cylinder	2,004.6	—
L. P. cylinder	4,467.7	—
Total	6,472.3	3,400†
I. H. P. per square foot of grate	25.68	11.58
Heating surface per I. H. P., square foot	1.79	2.57
I. H. P. per 100 square feet of wetted surface.	50.66	39.1
Distance, in statute miles	94	94
Speed, in statute miles	21.76	21.70
Speed, in knots	18.899	18.847
Slip of wheel over bucket, per cent	35.65	32.2
Depth of water in feet, start	57	57
minimum	35	35
maximum	77	77
average	61.31	61.31
Admiralty coefficient	178.2	225

*L. P. pass-over valve half open during last 1½ hours.
†Estimated.

"The trial resulted in the City of Erie beating the Tashmoo 45 seconds in a run of 94 miles—less than half a second a mile. With the exception of 4 minutes' stop of one of the blowers on the City of Erie, the main engines and auxiliaries on both steamers worked perfectly throughout the trial, all journals running cool. The boilers furnished a full supply of steam at all times. The admiralty coefficient should be considered in connection with the shallow water in which the run was made. It is estimated that the speed would have been at least one-quarter of a mile an hour greater had the steamers been in water of sufficient depth not to be influenced by the bottom.

"I regret that owing to leaking snifting valves no indicator cards could be taken on the Tashmoo. The power was estimated from a previous trial, when 3,120 H.P. was developed, with thirty-nine revolutions. Both steamers were taken off the regular service and prepared for the trial in a few hours. The City of Erie arrived in Cleveland from her regular run from Buffalo only four hours before the trial began. She was not dry-docked to clean bottom, though that was in fair condition. Her boats were taken in on main deck to reduce wind resistance. The Tashmoo was dry-docked, bottom cleaned and painted. Both steamers were run by their regular crews."

MR. STEVENSON TAYLOR'S SPIRITED DISCUSSION.

No sooner had Mr. Taylor finished reading Mr. Kirby's paper than he begged the right to be the first to discuss it. Mr. Taylor was on board the Erie during the race and moreover it was his firm, the W. & A. Fletcher Co., Hoboken, N. J., which built the engines of the Erie.

"Mr. Kirby," said he, "in his paper has given you only the solid facts of the City of Erie-Tashmoo race without embellishment and without calling your attention to many of the features of an interesting occasion. This race was the unusual result of steamboat talk—and I may say brag—as to who possessed the fastest steamer on the lakes. It was an unusual result in that a race occurred at all, and more unusual because all the care of an international yacht race was taken to make the affair satisfactory and decisive. Impartial judges and time keepers were selected. Government inspectors were present to see that no infraction of the law occurred. Two lanes were mapped out on the course so that the racers were always at least half a mile apart, broadside, from the start to the finish, the lanes being marked at the beginning, the middle and the end of the course by tug boats duly anchored in place. The choice of position was decided by lot, the Tashmoo winning and wisely choosing the outer course. Mr. Kirby has taken as a basis for the calculations in his paper the distance of the course to be 94 statute miles, but at the same time he correctly states that 'computed from the latitude and longitude of the lighthouses at Cleveland and Erie, and corrected for location of starting line, the distance is 94.31 miles.' You will concede that no boat could sail the course in less than this distance. Again he says, 'measured on the chart issued by the hydrographic office of the navy department, the distance is 95.25 miles.' Other authorities make the distance 94¾ miles.

"Those present at the race know that the boats each varied from the straight line and I have for my calculations on the race called the course 94½ statute miles. I trust you will agree that this is a fair assumption. You will note that the City of Erie is a freight as well as a pasenger boat with a double tier of staterooms and appurtenances for night travel, and that in order to have the wheels sufficiently immersed to utilize the power to a moderate degree even, it was necessary to carry a load of 250 gross tons. Even with this handicap weight considerable power was wasted, as is shown by the power per ton of displacement, by the high number of revolutions per minute and the corresponding slip of the wheel. The slip of wheel is given here for both boats, taking the diameter given for outside of buckets. This is not correct, of course, because the path of the outer edge of buckets through the water is not a circle of the diameter given for the wheel, but this method of determining slip answers for a comparison only. The Tashmoo slip is less than that of the City of Erie, showing a better hold on the water for the power developed. In this, however, the showing is not bad compared with fast side-wheel boats in Europe. The North sea steamer Marie Henrietta, on trial with 52.89 revolutions and 22.2 knots per hour, shows a slip of over 39 per cent. by the same rule used by Mr. Kirby. If we could possibly have lowered the shafts of the City of Erie to give the wheels proper immersion without carrying that extra 250 tons load, the result would have been, of course, much more favorable for the City of Erie; but they had to take the cart horse, just as she is, against the trotter and make the best of it.

"I now desire to call your attention particularly to the effect of the depth of water on the course. When the race was first projected the owners of the Tashmoo wished to have the race on Lake Huron, where the water is considerably deeper than in Lake Erie, but the owners of the City of Erie preferred Lake Erie and their choice was almost disastrous. You will remember that the Tashmoo chose the outside course, where the water is from 3 to 4 fathoms deeper than on the inner course left to the City of Erie. For the first hour and a quarter the boats ran neck and neck, any advantage for either being almost impossible to determine. At the expiration of this time I went to the pilot house to look at a Nicholson patent log, which shows the speed per hour being made by the boat, as well as making at the same time a chart of the speed. To my consternation, the pointer on the dial commenced to rapidly fall from 21.6 miles per hour, and as I had just left the engine room a few minutes before with engines running all right and making thirty-three revolutions, I at once jumped to the conclusion that something had happened to reduce the speed of the engines and I hastily returned to the engine room to find the engine close shut off and making almost 34½ revolutions, indicating shoal water. A look out of the gangways proved this to be correct by the sea following on the quarters. The Tashmoo, at this time in deeper water, immediately commenced to gain on the City of Erie rapidly and held the gain for some time. As soon as the City of Erie reached deeper water, however, she began to gain on the Tashmoo, but to those on the Erie it seemed a long time before the Erie reached and passed the Tashmoo. It was a full half hour before the 21.6-mile mark on the dial was again touched by the hand, and not until 70 ft. depth of water was reached did the City of Erie attain the highest speed of the race, 22.2 miles per hour. Mr. Kirby's diagram of curves of speed, power, slip and of depth of water shows at a glance the effect of the shoal water. This makes it very clear that had the race been in deeper water the difference at the end would have been more than 45 seconds, but 'all's well that ends well.' You will note that the City of Erie had not been dry-docked, had arrived in Cleveland from Buffalo on her regular run with passengers and freight only four hours before the race commenced. So far as the engine and boilers are concerned there was absolutely nothing done to prepare the boat specially for the race, because there was nothing needed to be done. The officers and crew had everything in proper condition. The City of Erie went from regular business to a great trial, returned the 95 miles to Cleveland, and in a short time, as soon as passengers and freight could be placed on board, left for Buffalo again on regular business. Machinery designed for a maximum of 4,500 H.P., developing under these conditions a maximum of 6,800 and an average of 6,400 H.P., like Mark Twain's jumping frog, has 'good points.'

"Let me call your attention to one more interesting item of Mr. Kirby's paper, which has nothing to do with the race: Amount of coal used for round trip, 350 miles, 175 miles each day, 67½ tons of 2,000 lbs. each; amount used for same round trip made in twenty-four hours, 55 tons. This latter was made during the summer months of the year when these boats, City of Erie and City of Buffalo, made regular day and night trips between the cities of Cleveland and Buffalo at an average speed of about 18½ miles an hour. I have no indicator cards showing the exact power developed, but 3,300 to 3,500 H.P. must be necessary and this gives a small consumption of coal per horse power per hour. The difference between the 55 tons and the 67½ tons per round trip is caused by keeping up steam all day in port when only a night trip is made and the moving of the boat from place to place at Cleveland to put freight and coal aboard."

Mr. Taylor's calculations of the City of Erie's performance differed from Mr. Kirby's in the following degree:

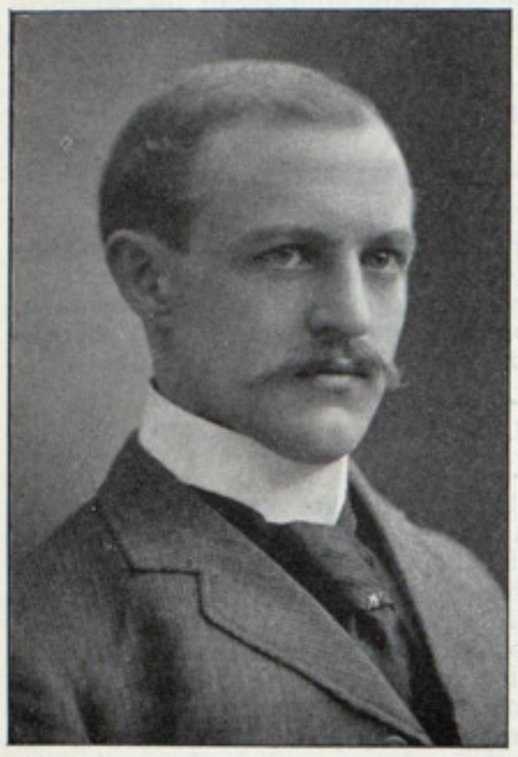
	Kirby's.	Taylor's
I.H.P. H.P. cylinder	2,004.6	1,981
L. P. cylinder	4,467.7	4,436
Total	6,472.3	6,417
I.H.P. per square foot of grate	25.68	25.46
Heating surface per I.H.P. square foot	1.79	1.8
I.H.P. per 100 square feet of wetted surface	50.66	50.23
Distance in statute miles	94	94½
Speed in statute miles	21.76	21.88
Speed in knots	18.899	19.
Slip of wheel over bucket, per cent	35.65	35.32

Mr. Andrew Fletcher, Jr., called the attention of the society to the fact

that photographs of the City of Erie and Tashmoo, which accompanied Mr. Kirby's paper, did not represent the vessels as they actually appeared upon the trip. The photographs, taken on excursion days, were merely used to show the general appearance of the vessels, but Mr. Fletcher feared that some of the members of the society might not understand that.

Mr. W. H. Fletcher, who was on board the Erie during the race, said that his principal occupation on board was in watching the Nicholson patent log and when it showed a perceptible falling off in the speed of the vessel he went to the stern to ascertain what the matter was. "There was at that time," said Mr. Fletcher, "six or seven fathoms of water under her. It is remarkable that she should feel the bottom, which she certainly did. I believe the winning of the race was due to the Erie's gathering way as speedily as she did. She crossed the line at a terrific clip."

Mr. W. I. Babcock thought the general impression in the lake region was that the Erie was stripped for the race but that the Tashmoo was not. Mr. Fletcher replied that no preparation had been made on board the Erie except to remove the life boats to a lower deck. He added that undoubtedly care had been taken to put a good coal aboard her. He added, too, that the Tashmoo would apparently come up and then drop back, a feature which several on board the Erie noted, and he wondered what was happening on the Tashmoo to cause these spurts.



PROF. H. C. SADLER.

"The Erie's flag poles were taken down," said Mr. Taylor; "that was the Erie's only stripping. The Tashmoo did not have her life boats down. Nothing was done to the Erie's condenser. I am told the Tashmoo covered the condenser with boiler felting and played water on it to increase its economy and that her engine room was in a pretty mussy condition. That is why they didn't take cards on the Tashmoo. On the other hand the Erie's engine room was in perfect condition all the time. The so-called dropping back of the Tashmoo was due to apparent variation in the direction of the bow. I took two trips on the Erie prior to the race. I found among the officers a tendency to run her light, but I thought that her wheels should have 5½ ft. dip. I recommended 5½ ft. but there was much opposition to this. I also discovered that nearly every one on the Erie had money up on the race, and not caring to submit my physical welfare to the tender consideration of the ship's officers should she lose, I compromised on the dip. However, we would have done better if we had more dip."

PAPERS OF PROF. H. C. SADLER AND MR. F. M. LEAVITT.

The second paper was upon the subject, "The Effect of Variation of Dimensions Upon the Stresses in a Ship's Structure," by Prof. Herbert C. Sadler of the school of naval architecture, University of Michigan. It was read by Secretary Capps in the absence of Prof. Sadler and was generally referred to as a very valuable addition to the transactions of the society on the subject of strength of ships, but it was not, unfortunately, attended by discussion, as it was too late in getting into print to admit of the careful examination that would be necessary on the part of members. It was therefore agreed that discussion might be presented at a later date in writing and that the same would be incorporated in the proceedings.

Prof. H. M. Bauer of Germany was to have presented a paper upon the subject "Graphic Calculations of the Stability of Ships," but was at the last moment unable to do so.

The fourth paper was upon the subject, "Power Consumed in Propelling the Whitehead Torpedo at Various Speeds," by Mr. Frank M. Leavitt. The paper was most interesting and dealt with tests made by the author with a view of ascertaining the efficiency of the motive power and the amount of power required to drive the torpedo at various speeds up to 33 knots per hour. At a later date the Review hopes to deal at length with this paper. It was of such a nature that it could not be discussed off hand. A vote of thanks was extended to Mr. Leavitt and leave given to the members of the society to submit printed discussion upon this paper also.

THE PRIZE PAPERS.

DEALING WITH THEORETICAL AND PRACTICAL METHODS OF BALANCING MARINE ENGINES—THE AUTHORS ARE HIGHLY COMPLIMENTED.

Mr. Frank M. Leavitt's paper regarding Whitehead torpedoes was read just before the hour for concluding the morning session of the first day, and it was then that Chairman Stevenson Taylor announced that Naval Constructor D. W. Taylor had won the prize in the balancing marine engine competition with his paper entitled "Labor Omnia Vincet," and that the author of the paper to which a special prize had been given was no less a celebrity than Rear Admiral George Wallace Melville.

As the concluding feature of the morning session Naval Constructor Taylor read his paper. Applause was generously bestowed upon this extraordinary young man, whose gifts can be appreciated with no less a word than genius. In mathematics he is acknowledged to be without a peer in the United States navy.

It would be idle to attempt to give within the limited confines of space given up to this meeting a complete abstract of Mr. Taylor's paper. Suffice it to say that in the opinion of the members of the society it closed the literature upon the subject of balancing marine engines. Its full title was "The Theoretical and Practical Methods of Balancing Marine Engines." It was illustrated to the minutest detail with drawings. In the main Mr. Taylor said:

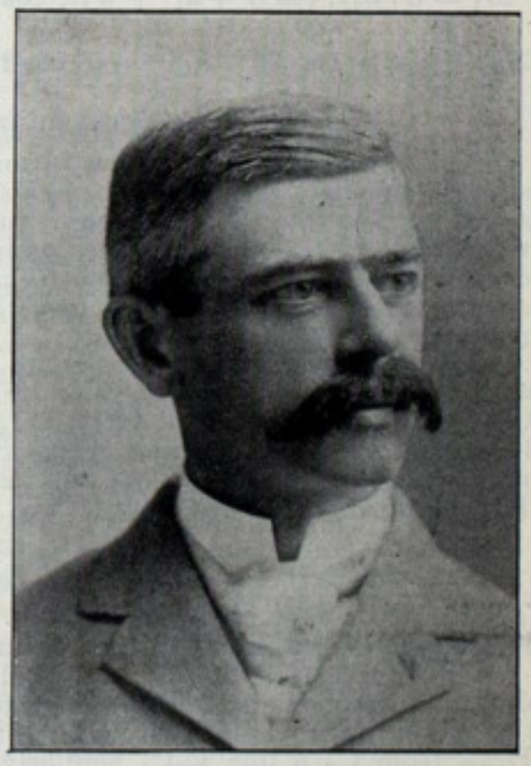
"Inasmuch as the principal object of balancing marine engines is to avoid the vibrations set up in ships through the operation of unbalanced engines, it may be as well, before taking up in detail the question of balancing engines, to point out that there are other factors to be considered in connection with the vibration of ships. A propeller may be well balanced and true, but if there is not a clean run of water to it, or, in other words, if the relative velocity of the water with reference to the ship is not uniform throughout the propeller disk, the forces acting upon each blade vary during a revolution. If, as a result of the varying forces upon the blades, there is a variation of the total force on the propeller during the revolution, we have resulting an unbalanced force, acting at the extreme after end of the ship, where it is most favorably situated to cause the latter to vibrate. Moreover the propeller itself may be out of balance or may have one or more blades out of true. Some years ago, Mr. Yarrow made some experiments on torpedo-boat vibrations, in the course of which he ran a boat under way and determined the nature and extent of the vibration. He then removed the propeller and ran the boat alongside the dock, determining again the nature and extent of the vibration. The result was that, for a given number of revolutions of the engines, there was very little difference between the vibration under way and the vibration alongside the dock with the propeller removed. The correct inference was that in this case the propeller had little or no tendency to cause vibration. This, however, was for a torpedo boat with fine lines, a fine run, and a very-carefully-balanced propeller. It does not follow that for ships which do not possess these characteristics the propeller has no effect upon vibration. That marked vibration can be caused by the propeller is a matter of common experience. Most of us have probably noticed at some time, in the case of a ship coming alongside a wharf, that when the engines are reversed marked vibration is very apt to make its appearance. The question of the vibration of ships is beyond the scope of this paper, but in view of the large amount of matter which has been published upon the question within the last fifteen years or so, covering the question of ships' vibrations as well as engine balancing, it is supposed that the members of the society are thoroughly familiar with the general phenomena.

"The matter of marine engine balancing has been the subject of much study and experimental investigation by distinguished engineers of every ship building country, and so much has been written about it that it is practically impossible at this time to put forward anything essentially new, or even to ascribe methods and results to the authors who first brought them forward. Suffice it to say that the state of the science is now such that, given an engine, it is possible to determine fully the unbalanced forces developed from it at any number of revolutions. In theory it is possible to balance perfectly any engine. In practice, however, so many weighty considerations, apart from those of balancing, must be taken account of that the design of correctly and satisfactorily balanced engines, which are satisfactory in other respects, is exceedingly difficult.

"In what I have to say I shall assume there is no slackness of bearings, so that the engine to be balanced is free from pounding or jar. An engine which is pounding because of slackness of bearings frequently causes, through its pounding, tremors throughout the ship, which are often confused with vibration proper, and are, indeed, almost equally objectionable. Pounding can frequently be reduced, or gotten rid of entirely, through adjusting the compression by proper valve setting. For this reason we sometimes find engineers under the impression that vibrations proper can be reduced or avoided by proper valve setting. This, however, is not the case, as general vibrations are affected only by the unbalanced forces due to moving weights or the propeller action.

GENESIS OF UNBALANCED FORCES.

"Let us consider first an engine with a single cylinder. If steam is in the cylinder, but the piston is not moving, the pressure upon the piston and the pressure upon the cylinder-head are equal and opposite. These pressures neutralize one another through the engine framing, and there is no external or unbalanced force communicated to the engine supports. If, however, the piston, with its attached weights, is moving and being accelerated, that portion of the steam pressure necessary to accelerate it is absorbed in giving energy to the moving parts, and hence is not transmitted to the engine framing. It follows that the pressure on the cylinder head which tends to move the framing in one direction is only partially balanced by that portion of the steam pressure upon the piston which is transmitted to the engine framing via the piston rod, connecting rod and crank shaft. It is obvious, then, that the unbalanced forces developed when a single-cylinder engine is revolving are equal and opposite to the forces necessary to accelerate or retard the moving parts as the engine turns over.



MR. FRANK M. LEAVITT.

"In one of the appendices to this paper will be found a detailed investigation of the geometry and mechanics of the motion in the case of a single-cylinder engine. Referring to the results in this appendix, we find that the weights of the moving parts of a single-cylinder direct-acting engine are equivalent to a reciprocating weight W, which moves with the crosshead and a revolving weight L, which is concentrated at the crank-pin axis. That if r denotes the crank-arm radius (equal to one-half the stroke) and $\emptyset$ the angle made by the crank radius with the direction of the cylinder axis, we have for a vertical engine an unbalanced force denoted by Q, due to the reciprocating weight W, and unbalanced vertical and horizontal forces denoted by V and H, due to the revolving weight L.

If R denotes revolutions per minute, the expressions for Q, V, and H are as follows:

$$Q = .000341\ r\ R^2\ W\left\{\cos\phi + \frac{\cos 2\phi}{n}\right\}$$

$$V = .000341\ r\ R^2\ L\ \cos\phi$$

$$H = .000341\ r\ R^2\ L\ \sin\phi$$

"Suppose, now, we have k parallel cylinders of equal stroke directly connected to the same shaft. Suppose that their axes are distant $l_1, l_2, l_3, \ldots\ldots l_k$ feet, respectively, from a fixed point on the shaft. Suppose their cranks are set at angles $a_1, a_2, a_3, \ldots\ldots a_k$ with a fixed radius of the shaft. Let $w_1, w_2, w_3 \ldots\ldots w_k$ denote the reciprocating weights, $L_1, L_2, L_3 \ldots\ldots L_k$ the revolving weights, r the common crank arm, R the common revolutions per minute, and ϕ the angle made by the fixed shaft radius (from which a_1, a_2, etc., are measured) with the plane through the axes of the cylinders. We need to determine the total or resultant unbalanced forces set up because of the rotation of the engine. Since the unbalanced forces in the various cylinders are not all in the same line, unbalanced moments will also make their appearance, and these, too, we need to determine. Consider, first, the reciprocating weights. Denote the unbalanced forces due to them in the respective cylinders by $q_1, q_2 \ldots\ldots q_k$. Evidently from the results demonstrated in the appendix we have:

$$q_1 = .000341\ r\ R^2\ w_1\left\{\cos(\phi + a_1) + \frac{1}{n}\cos 2(\phi + a_1)\right\}.$$

Similarly we have

$$q_2 = .000341\ r\ R^2\ w_2\left\{\cos(\phi + a_2) + \frac{1}{n}\cos 2(\phi + a_2)\right\},$$

and so on. It is convenient in determining the complete effect of the forces to use the ordinary device of applying, at the point through which moments are taken, two equal, opposite, and parallel forces for each unbalanced force considered. Each unbalanced force is thus reduced to a force acting through the point about which moments are taken, and a couple whose arm is the distance from the point about which moments are taken to the line of action of the unbalanced force. If we take moments about O and denote the moment of the couple, due to w_1 by m_1 we have

$$m_1 = q_1 l_1 = .000341\ r\ R^2 w_1 l_1\left\{\cos(\phi + a_1) + \frac{1}{n}\cos 2(\phi + a_1)\right\}$$

$$m_2 = q_2 l_2 = .000341\ r\ R^2 w_2 l_2\left\{\cos(\phi + a_2) + \frac{1}{n}\cos 2(\phi + a_2),\right\},$$

and so on. The expression .000341 r R^2 common to all our formulæ may be conveniently replaced by C.

"It is also convenient at this stage of analysis to separate the forces into two parts. That part varying as cos $(\phi+a)$ is conveniently called the primary force, and that varying as cos 2 $(\phi+a)$ is conveniently called the secondary force. Corresponding to the primary and secondary forces we have similarly the primary and secondary moments. Let Q_1 denote the resultant primary force due to all the cylinders. Let Q_2 denote the resultant secondary force due to all the cylinders. Let M_1 denote the moment of resultant primary couple due to all the cylinders. Let M_2 denote the moment of the resultant secondary couple due to all the cylinders. The forces being considered are all parallel, being those due to reciprocating weights, and their resultants are readily written down from well-known principles of mechanics. Evidently

$$Q_1 = C\ [w_1 \cos(\phi + a_1) + w_2 \cos(\phi + a_2) + \ldots\ldots + w_k \cos(\phi + a_k)]$$

$$Q_2 = \frac{C}{n}\ [w_1 \cos 2(\phi + a_1) + w_2 \cos 2(\phi + a_2) + \ldots\ldots + w_k \cos 2(\phi + a_k)]$$

$$M_1 = C\ [w_1 l_1 \cos(\phi + a_1) + w_2 l_2 \cos(\phi + a_2) + \ldots\ldots + w_k l_k \cos(\phi + a_k)]$$

$$M_2 = \frac{C}{n}\ [w_1 l_1 \cos 2(\phi + a_1) + w_2 l_2 \cos 2(\phi + a_2) + \ldots\ldots + w_k l_k \cos 2(\phi + a_k)].$$

INTRODUCTION OF GRAPHIC METHODS.

"From the above somewhat formidable looking expressions it is possible to calculate the resultant unbalanced forces and moments of unbalanced couples due to any known system of cylinders at any point of the revolution of the shaft. These expressions, however, are entirely too complicated to be of much value when the investigation of measures of amelioration is undertaken. Fortunately, the case is one to which graphic methods are peculiarly adapted.

"Referring to Fig. 4. Ox is the direction of the cylinder axes xOA $=\phi$. Draw OC_1 parallel to crank No. 1 and such that to a suitable scale $OC_1 = w_1$. Similarly draw OC_2, OC_3, OC_4, representing in direction and length the other cranks and reciprocating weights. Four cylinders are represented in the figure, but the process is applicable to any number. Draw the perpendiculars C_1Q_1, C_2Q_2, C_3Q_3, C_4Q_4. Evidently

$$OQ_1 = w_1 \cos(\phi + a_1)$$

$$OQ_2 = w_2 \cos(\phi + a_2), \text{ and so on.}$$

The algebraic sum of OQ_1, $OQ_2 \ldots\ldots OQ_4$ is OQ, which then represents in magnitude and direction the resultant primary force.

"Referring now to Fig. 5 instead of drawing all the cranks from O draw Ox and OC_1 as before. Then from C_1 draw a line C_1C_2 parallel to the second crank and representing in length its reciprocating weight. Draw from C_2 a line C_2C_3 similarly representing the third crank, and from C_3 draw C_3C_4 for the fourth crank. Drop the perpendicular C_4Q upon Ox, and OQ in Fig. 5 is exactly the same as OQ in Fig. 4. $OC_1C_2C_4$ in Fig. 5 is called the primary force polygon, and the angle AOC_4 is constant, whatever the value of ϕ. Evidently, if for OC_1, OC_2, and so on, we substitute a single crank at the angle referred to with OA, driving a reciprocating weight, represented by the length of OC_4, then as regards primary reciprocating forces, the single weight on the single crank is equivalent of the system of four weights on four cranks from which it was deduced. The line OC_4 is called the closing line of the primary force polygon. Clearly, if there were a fifth crank in the combination, parallel to C_4O and driving a reciprocating weight represented by the length C_4O, there would be no resultant primary force at any point of the shaft's revolution. In other words, the engine would be perfectly balanced as regards primary force. In practice, when drawing a primary force polygon, it is convenient to make OA correspond with a crank radius, and measure all other crank angles in the direction of rotation from the direction of this crank. I usually use the forward crank radius as the direction to which to refer all angles. Exactly in the same manner as the primary force polygon has been determined, it is possible to determine and delineate a primary couple or moment polygon, and the secondary force and couple polygons.

"In drawing the secondary force polygon the weights are, of course, $\frac{1}{n}$, those used in the primary force polygon, and the angles are doubled. This involves drawing angles greater than 360°, which can, of course, be readily done. When it comes to the couple or moment polygons, the lengths of the sides represent the moments of the couples, or the products w_1l_1, w_2l_2, etc. It is necessary, when considering actual engines, to choose a convenient point from which to measure l_1, l_2, etc., or, in other words, about which to calculate the moments of the couples. I find it convenient to use the point where the after cylinder axis intersects to shaft axis.

TREATMENT OF REVOLVING WEIGHTS.

"So much for the reciprocating weights. The forces due to them are all parallel to the cylinder axes—vertical in the case of a vertical engine and horizontal in the case of a horizontal engine. When, however, we consider revolving weights, we find from the appendix above referred to (a) that, for a single weight L, the forces V and H, parallel and perpendicular, respectively, to the cylinder axis, are given by the formulæ—

$$V = CL\ \cos\phi$$

$$H = CL\ \sin\phi.$$

Where, as before, C= .000341 rR^2.

"It is to be noted that these revolving forces are altogether primary. When proceeding from the case of a single cylinder, fully discussed in appendix A, to that with a number of cylinders acting on one shaft, the steps in connection with revolving weights are exactly the same as for reciprocating weights, and lead us to force and moment polygons for the revolving weights, both of which are primary only. It is to be noted that the closing line of a force polygon for revolving weights represents a revolving weight. I have now shown how to determine completely the resultant unbalanced forces and moments, at any point in the line of the shaft, due to any number of cylinders, their pistons, connecting rods, etc. —what may be called the main weights of the engine. There are, however, other moving weights which it is necessary to take account of—such as the valves, air pump gear, bilge pump gear, when fitted, etc. In appendix B, I have described and shown in detail methods of handling typical weights—valve gear, etc.—and it is believed that a careful study of the methods applied in appendix B will enable the student to determine proper results in any ordinary case. There is no satisfactory method for handling radial valve gears, because such gears do not give harmonic motion. The most satisfactory method for such gears is to determine an approximate harmonic motion for them and work with that. The exact method is, of course, to determine graphically the motion of the valve, and then its velocity and acceleration; but even after this is done we are unable to satisfactorily balance such gears with weights which have harmonic motion.

"It is convenient, as a rule, to draw the secondary force and moment polygons with sides the same length as those of the primary polygons, remembering always that the scales for the secondary polygons are n times larger than the scales for the corresponding primary polygons.

"This completes the description and demonstration of methods for the determination of unbalanced forces and moments of unbalanced couples in a known engine. The unbalanced force acts through the point about which moments are taken. In theory the unbalanced force and couple can always be reduced to a single force acting at some other point of the shaft axis. But as this theoretical point shifts along the axis (unless the closing lines of force and moment polygons are parallel) as the shaft revolves, and is hence generally outside the engine framing, it is not necessary, as a rule, to determine its position, it being really simpler to consider always the force acting at and the moment about one point suitably chosen.

CONDITIONS ESSENTIAL TO BALANCE.

"I come now to the question of balancing engines so as to reduce or extinguish entirely unbalanced forces. The methods previously explained will always enable us to determine whether or not an engine is balanced, and modifications of them will be found very useful when searching for methods to obtain a balance. I shall consider, primarily, the usual type of marine engine, the vertical inverted, where the cylinders are arranged in line above the shaft. There are four conditions which must be fulfilled in a perfectly balanced engine.

"First. As it revolves the combined center of gravity of the moving reciprocating weights must remain at a constant distance from the axis. When this is the case, there can obviously be no resultant inertia forces and hence no external force caused by the motion of the reciprocating weights.

"Second. If we substitute for each moving reciprocating weight another one proportional to the product of the weight by its distance parallel to the shaft from a fixed point on the shaft axis, the center of gravity of this derived system of weights must remain at a constant distance from the axis as the shaft revolves. When this is the case and the first condition is complied with, there can be no external couple due to reciprocating weights.

"Third. The center of gravity of all revolving weights must be in the shaft axis. When this is the case, there can be no external force due to revolving weights.

"Fourth. If for each revolving weight we substitute a weight proportional to the revolving weight, multiplied by its distance parallel to the shaft from a fixed point on the shaft axis, the center of gravity of this derived system must be in the shaft axis. When this is the case and the third condition is complied with, there can be no couple or moment from revolving weights.

"The above essential conditions for perfect balance have been known

for years. It is evident that if all the force and moment polygons, as explained by me, are closed, the four conditions are fulfilled—otherwise, they are not fulfilled. It is evident, too, that if the four conditions are fulfilled for uniform rotation, they are necessarily fulfilled for non-uniform rotation.

"It will be noted that I have throughout made a marked distinction between the reciprocating and the revolving weights. This is because forces and moments due to reciprocating weights are constant in direction, remaining always in the plane of the cylinder axis, and vary in magnitude as the shaft revolves. The forces and moments due to revolving weights, on the other hand, are constant in amount, but vary in direction as the shaft revolves. The components of the revolving forces and moments, resolved parallel to any one direction (say the plane of the cylinder axes), are variable in amount, because the constant forces and moments are variable in direction. It is quite possible to balance the forces and moments of reciprocating weights by the components parallel to the plane of the cylinder axes due to revolving weights, but this renders it impossible to balance the forces and moments of the revolving weights perpendicular to the plane of the cylinder axes. If reciprocating weights are balanced by revolving weights the latter must have unbalanced resultant components in the plane of the cylinder axes equal and opposite to the unbalanced resultants of the reciprocating weights. But then the unbalanced resultants of the revolving weights in the direction perpendicular to the plane of the cylinder axes are equally great, and in this plane there is nothing to oppose or balance them. Cases are supposable where we would be warranted in trying the effect of balancing reciprocating weights by revolving weights. Suppose, for instance, serious vertical vibrations occur at the revolutions at which it is most desirable that the engines

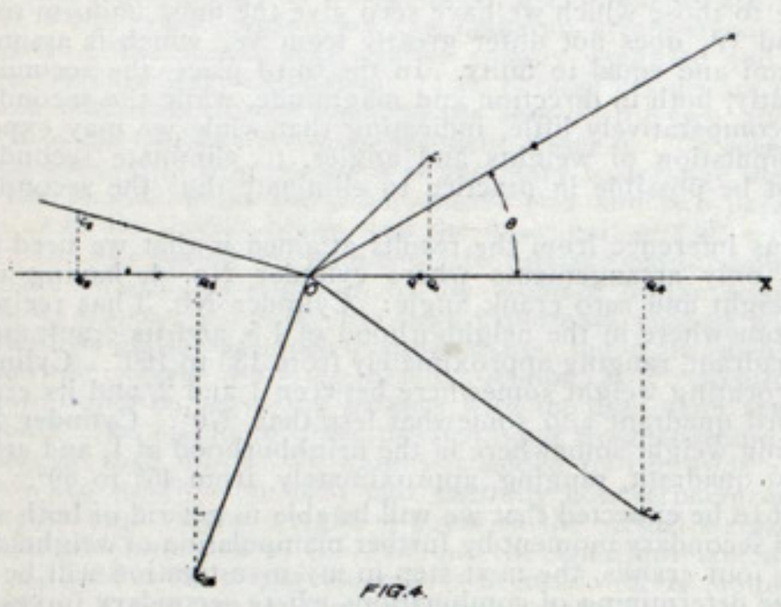


FIG. 4.

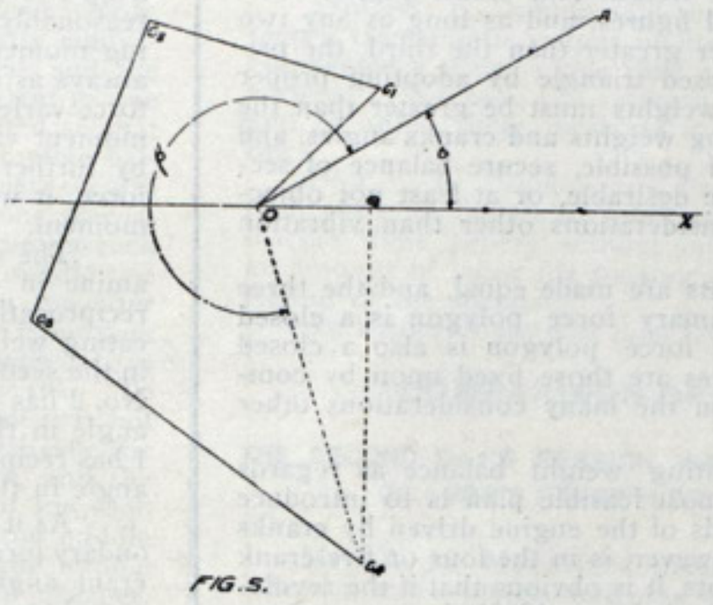


FIG. 5.

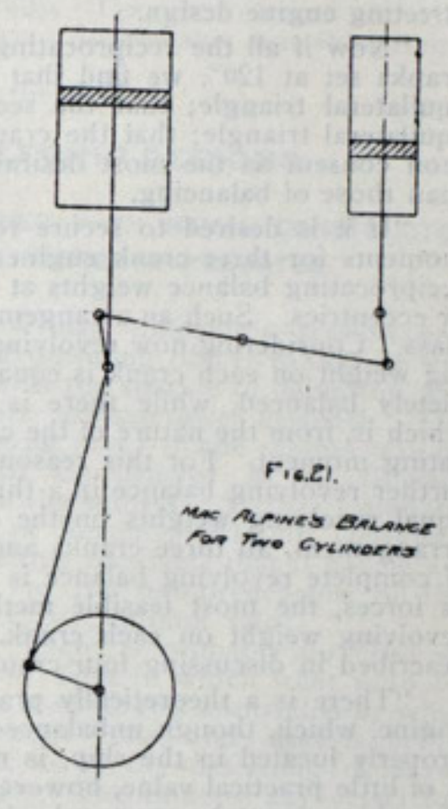


FIG. 21.
MAC ALPINE'S BALANCE FOR TWO CYLINDERS

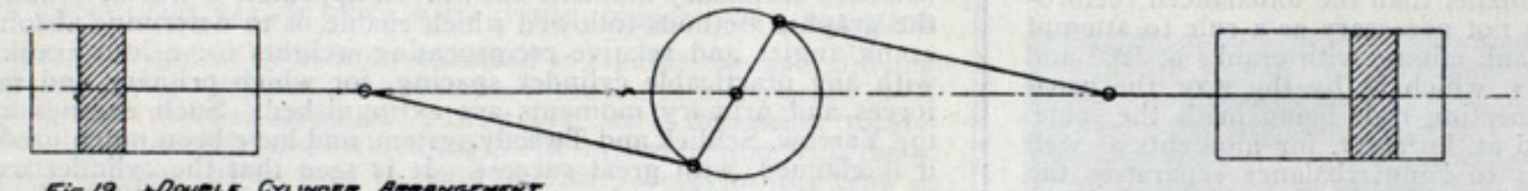


FIG. 19 DOUBLE CYLINDER ARRANGEMENT. COMPLETELY BALANCED

FIG. 20.
DOUBLE CYLINDER ARRANGEMENT. CRANKS AT 180 DEGREES

ILLUSTRATING NAVAL CONSTRUCTOR TAYLOR'S PAPER ON "THEORETICAL AND PRACTICAL METHODS OF BALANCING MARINE ENGINES."

should run, and are evidently due to synchronism between the revolutions of the engine and the natural period of vibration of the ship in a vertical plane.

"We would be warranted in using revolving weights to produce vertical balance, on the chance that the unbalanced horizontal forces thus produced would not synchronize with the period of horizontal vibrations of the ship, and that thus beneficial results would be produced. Revolving weights, however, producing only primary forces and moments, cannot balance the secondary forces and moments of reciprocating weights. Moreover, in actual unbalanced engines the unbalanced forces and moments from reciprocating weights are nearly always much larger than those from revolving weights. So, to balance by revolving weights the primary forces and moments from the reciprocating weights, we must largely add to the unbalanced revolving forces and moments perpendicular to the plane of the reciprocating weights without being able to reduce at all the secondary forces and moments from the reciprocating weights. It is, then, clearly more logical and satisfactory to attack the problem in detail—balance reciprocating weights by reciprocating weights only, and revolving weights by revolving weights only.

"It is evident from what has gone before, that the more sides to our force and moment polygons the more readily they can be closed by manipulating weights and crank angles. That is to say, the more numerous the cranks of an engine the more readily it can be balanced without using special balance weights, which should be avoided where practicable. Also, for an engine of given power and revolutions per minute, the more numerous the cylinders the lighter the moving parts of the individual cylinders. After making due allowance for the fact that the engines develop different powers at different revolutions, the ameliorative effect, as regards vibrations, of increase in the number of cylinders is obvious.

"I shall proceed now to discuss the question of balancing ordinary vertical inverted engines of 1, 2, 3, 4 and 5 cranks. As a rule, there is one cylinder to each crank, and this is assumed to be the case unless otherwise stated. Main weights only will be considered at first.

ENGINES WITH ONE CRANK.

"In Appendix A the resultant forces due to the inertia of moving parts of a single-crank engine are fully determined. With one cylinder there are no unbalanced moments, and partial or complete balance cannot be obtained by judicious arrangement of moving parts of several cylinders. It is possible to balance the primary reciprocating forces by introducing large revolving weights, but the strong objections to this course have already been pointed out. It is, however, practicable to balance completely the revolving weights by weights on the shaft opposite the crank pin, and this should always be done. If it is then required to balance the reciprocating weights, the most practicable method is to use lever-driven balance weights. The introduction of such a weight evidently results in an unbalanced couple. If this must be avoided, two weights may be used. It is to be observed that in the case of a single-cylinder engine with an air pump driven by a lever from the crosshead, the reciprocating air-pump weights partially balance those of the cylinder, and by making them of the proper weight complete balance may be obtained. But then the air-pump weights would be impossibly heavy. The small use now made of single-cylinder engines for marine purposes renders the question of the balance of such engines one of little practical importance.

ENGINES WITH TWO CRANKS.

"It is entirely impossible to close either force or moment polygons of two crank engines without introducing other sides, that is, with the two-cylinder engine as usually arranged bob weights must be used to improve the balance. But these must be driven by cranks or their equivalents—eccentrics—resulting in an engine with more than two cranks. It is probably the best practice, if two-crank engines must be balanced, to secure revolving balance by balance weights opposite each crank, and then for reciprocating balance use lever balance weights for each cylinder, as in the case of a single-cylinder engine. There are special arrangements, however, for two-cylinder engines, which secure perfect balance, though the usual arrangement of two cranks at 90° must then be departed from.

"Fig. 19 shows a perfectly balanced two-cylinder arrangement. The cranks are 180° apart, and the cylinders have their axes in line and on opposite sides of the shaft. It is necessary in practice to use a double connecting rod and double crank for one cylinder, these being in each case of the same total weight as the corresponding parts for the other cylinder. Of course, too, the reciprocating parts of each cylinder must be of the same weight. It is obvious on inspection that this engine fulfills the four conditions for balance as regards forces, since, as the shaft revolves, the center of gravity of the moving weights does not change. Also, since the two cylinders are in line, there are no moments developed. The arrangement of Fig. 19 is not applicable to marine engines. It is used for fan and automobile engines. To save expense, steam supply complications, etc., the arrangement shown in Fig. 20 is often adopted, even where that of Fig. 19 could be introduced, and it is used for small marine engines where Fig. 19 is not applicable. Fig. 20 is often considered equivalent to Fig. 19, but such is far from being the case. A couple is introduced, since the two cylinder axes are not in the same line, and the arrangement is the worst possible for secondary forces. Consider an engine where the connecting rod is four cranks long, for instance. The primary reciprocating force is abolished if the moving parts are made of the same weight, but, as the secondary forces are added to one another, we have an unbalanced secondary force equal in amount to that due to half of one reciprocating weight.

"When we consider revolving forces, the arrangement of Fig. 20 is

objectionable only in the introduction of an unbalanced moment. The primary forces are neutralized as for the reciprocating weights, and there are no secondary forces from revolving weights. If the most complete revolving weight balance is wanted, however, the revolving weights for each crank must be separately counterbalanced. The arrangement of Fig. 20 is a decided improvement, as regards vibrations, over the customary arrangement where the cranks are at 90°. But the latter is preferable from certain practical considerations; for instance, it has no dead center, and gives a much more uniform turning moment.

"A two-cylinder arrangement has recently been brought forward by MacAlpine, which is superior to that of Fig. 20 in that it eliminates secondary forces. It is shown diagrammatically in Fig. 21. It gives perfect balance as regards reciprocating weights, and its unbalanced couples are athwartships instead of fore and aft, and are not likely to cause objectionable vibration. This arrangement has the practical objections mentioned above to that of Fig. 20, and a few others of its own, due to increase in number of working parts, use of rocking levers, etc. It is, however, a simple and elegant solution of the problem of complete two-cylinder balance, and by doubling it—using two pairs of cylinders on one shaft—it can be applied to triple and quadruple expansion engines.

ENGINES WITH THREE CRANKS.

"For three-crank engines the force polygons are three-sided figures and the moment polygons two-sided figures. We have now reached a sufficient number of cranks to allow reduction of unbalanced forces by properly choosing reciprocating weights and crank angles. Also, in these days of triple expansion, all marine engines of importance have at least three cylinders, so the three-crank case is the first one I have discussed of practical importance. The moment polygons—two-sided figures—obviously cannot be closed by variation of weight and crank angles. The force polygons are, however, three-sided figures, and as long as any two of the reciprocating weights are together greater than the third, the primary force polygon can be made a closed triangle by adopting proper crank angles. The condition that two weights must be greater than the third allows a wide choice of reciprocating weights and cranks angles, and we should make a choice which will, if possible, secure balance of secondary as well as primary forces and be desirable, or at least not objectionable, as regards the very many considerations other than vibration affecting engine design.

"Now if all the reciprocating weights are made equal, and the three cranks set at 120°, we find that the primary force polygon is a closed equilateral triangle; that the secondary force polygon is also a closed equilateral triangle; that the crank angles are those fixed upon by common consent as the most desirable from the many considerations other than those of balancing.

"If it is desired to secure reciprocating weight balance as regards moments for three-crank engines, the most feasible plan is to introduce reciprocating balance weights at the ends of the engine driven by cranks or eccentrics. Such an arrangement, however, is in the four or five-crank class. Considering now revolving weights, it is obvious that if the revolving weight on each crank is equal (cranks being at 120°), forces are completely balanced, while there is left an unbalanced revolving moment, which is, from the nature of the case, smaller than the unbalanced reciprocating moment. For this reason, it is not necessary as a rule to attempt further revolving balance in a three-crank engine with cranks at 120° and equal revolving weights on the cranks, which is, by the way, the usual arrangement, all three cranks and connecting rods being made the same. If complete revolving balance is aimed at, however, for moments as well as forces, the most feasible method is to counterbalance separately the revolving weight on each crank. Or the methods of revolving balance described in discussing four-crank engines may be applied.

"There is a theoretically practicable arrangement of the three-crank engine, which, though unbalanced as regards both forces and moments, if properly located in the ship, is nearly balanced as regards vibration. It is of little practical value, however, owing to the fact that the nodal points of a ship cannot be accurately determined in advance of the ship's completion, and in fact, are subject to changes of location with change of loading the ship. For three-crank engines in practice the nearest approach to balance is obtained by adopting cranks at 120°, and making the reciprocating and revolving weights for each crank the same. A slightly better balance may be obtained by fully balancing with counter-weights the revolving weights for each crank, thus extinguishing revolving moments; but as reciprocating moments, which are usually larger than the revolving moments, are necessarily left unbalanced, it appears hardly worth while, as a rule, to add weight, complication, and expense to a three-crank engine for the purpose of avoiding revolving moments. If a three-crank engine, balanced as regards forces, is placed about the center of the length of the ship, its unbalanced moments are least likely to set up vibrations because unbalanced moments are most harmful where a vibratory node is located, and at the center of the ship there is nearly always a loop. Torpedo boats with three-crank, equally weighted engines located about the center of length have give fairly satisfactory results as regards vibration.

ENGINES WITH FOUR CRANKS.

"For a four-crank engine the force polygons are four-sided figures and the moment polygons three-sided figures. Evidently, then, the balancing possibilities, so to speak, in the case of a four-crank engine, are decidedly superior to those of engines previously considered. The large and increasing use, of late years, of triple-expansion engines with two L. P. cylinders, and of quadruple expansion engines, has, through the use of four cranks, increased the opportunities for balancing and the development of balanced types of engines. Progress in marine engine balance during the last ten years has been made almost entirely with four-crank engines. It is necessary, then, to consider most thoroughly the balancing possibilities and limitations of such engines.

"Before beginning this task, I desire to call attention to the important fact that the usual spacing of cranks of 90°, found in the case of four-crank engines, is essentially inferior as regards uniformity of turning moment. If a four-crank engine has four simple, double-acting cylinders, the 90° spacing is equivalent, as regards turning moment, to two cranks at 90°. For the turning moment on a crank at 0° in such an engine is the same as that on its opposite crank at 180°. and the two cranks at 90° and 270° are equivalent to one crank with double moment at either 90° or 270°. To secure the most uniform turning moment for double-acting engines, the crank should be at or opposite the angles obtained by dividing 180°, not 360, by four, the number of cranks. Thus, starting with the first crank at 0°, the second should be at 45°, or 225°; the third at 90°, or 270°; and the fourth at 135°, or 315°. This conclusion, obvious for four-crank simple engines, is readily shown to apply to quadruple engines, where about the same power is developed in each cylinder. We shall see later that the crank angles for four-crank engines, which it is necessary to adopt for balancing, approximate fairly closely to those most favorable for uniform turning, so that a balanced four-crank engine is also one with a more uniform turning moment than if the 90° crank spacing is adopted. It may be asked why, in a three-crank engine, cranks equally spaced around the whole circumference give the best turning moment. The answer is that (since in a double-acting engine the turning moment of a crank is equivalent to that of a crank directly opposite) the usual three-crank arrangement at 0°, 120°, and 240° is equivalent to one at 0°, 120° and 60°; and in the latter the cranks are equally spaced over the first 180° of the crank circle.

"The mathematical investigation of the balancing possibilities in connection with four-crank engines is quite feasible, though laborious. I have attacked the problem by determining first, throughout the practicable range of relative reciprocating weights and cylinder spacings, a large number of arrangements of crank angles, etc., for engines which are completely balanced primarily, and then determined the unbalanced secondary forces and moments for these engines. It will be observed in the first place, that where the crank angles are such as to give an evidently inferior turning moment, the resultant secondary force is usually large, and the relative reciprocating weights such as would be very difficult to obtain in practice. In the second place, for arrangements where W_2 and W_3 range from 1 to 1.5, the secondary forces are not large, the crank angles approach reasonably close to those which we have seen give the most uniform turning moment, and W_1 does not differ greatly from W_4, which is assumed always as constant and equal to unity. In the third place, the secondary force varies greatly, both in direction and magnitude, while the secondary moment varies comparatively little, indicating that while we may expect, by further manipulation of weights and angles, to eliminate secondary force, it will not be possible in practice to eliminate thus the secondary moment.

"The obvious inference from the results attained is that we need examine in detail only arrangements where cylinder No. 4, having unit reciprocating weight and zero crank angle: Cylinder No. 3 has reciprocating weight somewhere in the neighborhood of 1.5, and its crank angle in the second quadrant, ranging approximately from 135 to 160°. Cylinder No. 2 has reciprocating weight somewhere between 1 and 2, and its crank angle in the third quadrant and somewhat less than 270°. Cylinder No. 1 has reciprocating weight somewhere in the neighborhood of 1, and crank angle in the first quadrant, ranging, approximately, from 45° to 60°.

"As it is not to be expected that we will be able to get rid of both secondary force and secondary moment by further manipulation of weights and crank angles for four cranks, the next step in my investigation will be directed toward the determining of combinations where secondary forces, as well as primary forces and moments, are extinguished, and the resulting unbalanced secondary moment known. In appendix C will be found detailed the graphic methods followed which enable us to determine absolutely the crank angles and relative reciprocating weights for a four-crank engine, with any practicable cylinder spacing, for which primary and secondary forces and primary moments are extinguished. Such engines are upon the Yarrow, Schlick and Tweedy system, and have been much used abroad, it is claimed, with great success. It is seen that the cylinder axes once located, the crank angles and relative weights follow. While theoretically any order for the cylinders may be chosen, in practice, owing to the fact that the lightest weights must be on the end cranks, and that uniform turning moments are desirable, it is advisable to adopt the general arrangements outlined below.

"For four-cylinder triple-expansion engines the two L. P. cylinders should be outside, and their moving part should be as light as possible. Each L. P. cylinder does only about half the work of the H. P. or M. P., and it is desirable to have the L. P. connecting rods, crank pins, etc., reduced in due proportion. For four-cylinder quadruple expansion engines the H.P. and M^1P. cylinders should be outside and the M^2P. and L. P. inside. Care must be taken to design the L. P. piston as light as practicable, and it is advisable to have the air pump, if worked by a lever, driven from the L. P. crosshead, as thus the L. P. reciprocating parts are virtually lightened. It is advisable to have the forward pair of cylinders as close together as practicable, and the after pair also as close together as practicable. This result is facilitated if the valves for the two outer cylinders H. P. and M^1P. are placed at the ends of the engine, and the valves for the two inner cylinders M_2P. and L. P. in the middle. Balance can be had without the precautions noted above, but with much greater additions of weight than would otherwise be needed.

"With a four-crank engine, balanced as regards the reciprocating weights, there are so many ways of obtaining revolving balance that it becomes a question of selecting that one having most practical advantages as regards simplicity and cheapness. The ideal method as regards balance alone is to fit proper counter-balance weights opposite each crank. If, however, the revolving force and moment polygons are plotted, it will be found that equally complete balance can be secured with less total addition of weight. If moments are taken about the after crank as usual, a revolving weight at the forward crank at a suitable angle will close the revolving moment polygon. This will, of course, mean an additional side to the revolving force polygon, but the latter can now be closed by a suitable weight at the proper angle at the after crank. In practice it is not convenient, as a rule, to apply balance weights at the cranks, unless they are on or opposite to the crank. So the most feasible plan in practice is to fit two revolving counter-balance weights, one aft of the engine framing and the other forward. The turning wheel can usually be made use of for the attachment of one of these weights, and if the forward end of the shaft is extended two or three inches, a wheel or disk for a forward balance weight is readily attached. Once the correct force and moment polygons are plotted, the amounts and angles of these weights are readily determined.

"Before finally balancing revolving weights it is well to take advantage of any obvious methods for reducing the unbalanced resultants. This may often be done, for instance, by drilling holes in one or more solid crank

pins, or filling one or more, when they are hollow, with lead or similar devices. The force and moment polygons will always show what is wanted and indicate the direction along which to work.

ENGINES WITH FIVE CRANKS.

"It is not necessary to enter into a detailed analysis of the case of five-crank engines. With them perfect balance can be secured in a very simple manner. We have seen that with three-crank engines, with cranks equally weighted and spaced, both primary and secondary forces are balanced. The balance, as regards forces, is even more complete than this. I have, throughout, taken the acceleration of reciprocating parts as proportional to

$$\cos \phi + \frac{\cos 2\phi}{n}.$$

"MacAlpine has shown that an even closer approximation is given by taking the acceleration as proportional to

$$\cos \phi + \cos 2\phi \left(\frac{1}{n} + \frac{1}{4} \cdot \frac{1}{n^3} + \frac{15}{128n^5} + \ldots\ldots \right) - \cos 4\phi \left(\frac{1}{4n^3} + \frac{3}{16n^5} + \ldots\ldots \right) + \cos 6\phi \left(\frac{9}{128n^5} + \ldots\ldots \right).$$

"Now, with a three-crank engine, with cranks equally weighted and spaced, the resultant force due to terms involving cos ϕ, cos 2ϕ and cos 4ϕ, is zero, so that we may consider that primary, secondary and tertiary forces all vanish. Evidently, then, we should obtain almost an ideal balance with three-crank engines, as above, were it not for the fact that the cylinder axes, being not in the same line, moments are produced. Now, with a five-crank engine, we can make an arrangement virtually equivalent to a three-crank with cranks equally weighted and spaced, and the three cylinder axes coincident. Two parallel cranks are equivalent to one crank with weight on it equal to the sum on the two, and located so that each of the two has the same moment about it. To secure complete balance, then, with five cranks, it is necessary to arrange the heaviest weight in the middle, make the other cranks two and two parallel, one pair at 120° with the middle crank, and the other pair at 240°. Considering each pair, the moment of the weight on the forward crank about the middle one must be equal and opposite to the moment of the weight on the after parallel crank. There has not been experience enough with the five-crank system to settle the best arrangements, but it is readily adapted to a quadruple engine with the first or second M. P. divided into two. To secure complete revolving balance with the five-crank arrangement is not difficult. As a general thing the revolving weights would naturally be the same for each crank. If weight is added to the middle crank, and the revolving weights on each pair partially counterbalanced until for each pair the total virtual weight is equal to the virtual weight on the middle crank, and each one of the pair has the same moment about the middle crank, perfect revolving balance is secured. It is simpler and cheaper, however, to use two revolving balance weights, spaced as far apart as possible, as in the case of four-crank engines.

BALANCE INCLUDING VALVE GEAR AND OTHER SECONDARY WEIGHTS.

"An engine might be completely balanced as regards the main moving parts and yet develop very serious unbalanced forces due to its other moving weights, such as valve gears, air pumps, etc. It is impossible to discuss in detail the possible cases which may arise in connection with these. In appendix B have shown how to determine the effects of any type of weight likely to be met with in practice. In balancing, skill and experience in applying the methods I have described are essential, but the modifications necessary to handle valve gears and other secondary weights are very simple in principle. Take an eccentric valve gear, for instance. The eccentrics driving it will be set at certain angles ahead or behind the crank of the cylinder; and the position of the crank once determined, the effect of the valve gear weights can be obtained. So when balancing a four-crank engine, for instance, first neglect the valve gears, and determine crank angles and main weights. Then using these crank angles, determine the resultant unbalanced forces due to the valve gears. Next make a second approximation to the main gear weights and angles, so determining them that they are not in perfect balance with each other but balance the valve gears. In rare cases it may be necessary to repeat this process, but as a rule the second approximation to the main crank angles and weights is practically exact. The above is peculiarly applicable to the four-crank engine, where crank angles are varied in balancing. Engines with three or fewer cranks cannot be balanced anyhow. For five-crank engines with cranks 120° apart, the valve gears must be balanced independently like the main gears. This is very simple, if the valves all supply steam on the outside or all on the inside. Then the eccentrics all have practically the same angular advance, and balancing is a question of weighting, which is easily arranged for. Revolving secondary weights are easily combined with the main revolving weights, and if two revolving balance weights, spaced as far apart as possible, are used, they can readily be arranged to balance all revolving weights, main and secondary. One great advantage of this method of securing revolving balance is, that with provision made for the two balance weights, their exact amounts and angles need not be settled until the engine is practically completed and the exact revolving weights to be balanced known.

"In conclusion, I would recommend in the strongest manner that when designing an engine, whether for balance or not, complete force and moment polygons be always drawn, representing the effects of every moving weight, the weights being estimated. For completed engines, actual weights should be obtained and used for the polygons."

REAR ADMIRAL MELVILLE'S PAPER.

The only paper read during the afternoon session of first day was Rear Admiral George Wallace Melville's upon the prize subject, "Theoretical and Practical Methods of Balancing Marine Engines." It was a matter, both of surprise and congratulation to the society that both these minds, working in ignorance of each other, should have pursued almost the same identical lines. As both papers were so nearly alike, discussion upon Mr. Taylor's was withheld until Admiral Melville's could be read. Then both were discussed together. Admiral Melville, much to the regret of the society, was not present, but he found a most responsive reader in Mr. W. M. McFarland, who interpreted the admiral's paper in a delightful manner. The admiral's paper is of so exhaustive a character that the Review withholds the publication of it until a later issue when it will be fully set forth. It is the admiral's belief that the MacAlpine system is the best solution of the problem of engine balancing that has thus far appeared. For this reason he placed in strong contrast the features of this and the Yarrow-Schlick-Tweedy system, inasmuch as the latter has been, applied in more cases than any other system which claimed to give a reasonably complete solution of the problem. He would like to see the MacAlpine system tested and believes that the results will amply compensate for the demonstration. It was doubtless a great tribute to the exhaustive labor which marked these papers, that when discussion was called for upon them the whole auditorium was silent.

"College professors are the only persons competent, outside of the authors themselves, to discuss these papers," said Mr. McFarland. "As a rule the rest of us are inclined to take a formula out of a book and go ahead."

Mr. J. C. Kafer moved that the thanks of the society, and indeed of the engineering world as a whole, be given to the authors. He added that the man who offered the prize of $100 certainly got the worth of his money.

Mr. W. D. Forbes discussed the papers on the purely practical side. He was willing to leave to such minds as Taylor and Melville the great labor which they involved and to content himself with seeing that the mechanical production of the designs was faithful to the smallest degree. Indeed he held that the success of their theories frequently depended upon the manner in which the mechanical part of the work was done. The failure of the smallest nut might disturb the success of a design.

Prof. W. F. Durand said that while the past ten or twelve years had seen a tremendous output of literature on this subject, these papers encompassed a wider scope than all and practically brought the subject to a close. "We have the solution well in hand," said he, "and we should aim to adopt these methods to practical work instead of seeking new ones."

Prof. C. H. Peabody and Prof. D. S. Jacobus were both unstinted in their praise of the authors, but said that not even college professors could discuss these papers without infinite study. They represented too vast an amount of labor for passing discussion. Indeed this was the general feeling of the society.

An adjournment was then taken for the day.

COMPARISON OF BATTLESHIP DESIGNS.

THE SECOND DAY'S SESSION WAS OPENED WITH NAVAL CONSTRUCTOR GILLMOR'S PAPER—LIVELY AND INTERESTING DEBATES.

Mr. W. M. McFarland presided at Friday morning's session, and indeed a more entertaining and excellent presiding officer cannot be imagined. He enlivened the proceedings with the sparkle of delightful wit, and, moreover, transacted business with considerable despatch. The opening paper of the session was by Naval Constructor H. G. Gillmor upon the subject, "A Brief Comparison of Recent Battleship Designs." Omitting one table that is not necessary to the comprehension of the paper, Mr. Gillmor said:

NAVAL CONSTRUCTOR H. G. GILLMOR.

"There is probably no class of design work in which what is to be done is so largely controlled by what has been done, and what is being done, as in the designing of naval vessels. The value of any vessel for naval purposes must necessarily be determined finally not only by the features embodied in the vessel itself, but by the characteristics of the vessels against which she may be opposed. It is this which makes the study of the development of foreign designs a necessity, and determines the characteristics of the vessels of the several classes which may at any time be in course of design. While from time to time new types of vessels have been introduced and developed, there has always been a type of vessel recognized in each period as the main strength and backbone of naval force; and this type has always been designated the battleship. It is to the consideration of the designs of vessels of this class of the present period that attention is asked. For the purposes of comparison there have been chosen the most recent designs of the several principal naval powers; and the comparison will be confined to the design conditions for those features which directly contribute to the naval value of each unit—that is to say, the armament, the protection, the speed, and the coal supply. The designs chosen are Great Britain, the Duncan; Germany, the Wittelsbach; Russia, the Borodino; Italy, the Vittorio Emanuele; Japan, the Mikasa, and the United States, the Virginia. In each case there are represented two or more vessels, the naval features of which are virtually the same as that of the vessel named. The information available with respect to the latest French battleship design is so meager as to have made it impracticable to include it in the comparison proposed. Full data is given in the table on the following page.

"Even to the casual observer considerable variation in the design features must be noticeable; and since this variation may be taken as an indication of the range within which designers of the present have considered it advisable to limit these elements, brief notice of them may not be without value. In armament, uniformity of practice is found in the location of the heavy guns, but in their number and caliber a considerable range is noticeable. With but two exceptions 12-in. guns have been chosen, and, with a single exception, the number of heavy guns is four,

mounted in pairs, two forward and two aft. In the Mikasa, four 10-in. guns make up the heavy battery, though in other vessels of practically the same general characteristics built for the Japanese government, 12-in. guns have been employed. In the Wittelsbach design, four 9.4-in. guns have been adopted, marking the limit in lightness of caliber of the first caliber guns in battleships. The one exception to the number four for the heavy guns is in the Vittorio Emanuele, where two 12-in. guns, mounted one forward and one aft, have been chosen. In the guns of second caliber an almost equal range in caliber and a considerable variation in arrangement are noticeable. In all but two of the designs under consideration what may be called a central battery, more or less extended, is employed. This central battery reaches the extreme of concentration on the Wittelsbach, and is most extended on the Virginia. In two out of the six designs the secondary caliber guns are mounted exclusively in such a central battery, with the addition of four guns of second caliber in isolated casemates, giving bow and stern fire. In two others, in addition to the central battery, a portion of the second caliber guns are mounted in turrets, giving fire over a considerable arc from directly ahead or directly astern. In these turrets there are, in one case, guns mounted in pairs, and, in the other, single guns. The Borodino and Vittorio Emanuele mount the second caliber guns entirely in such turrets. In the Wittelsbach, the central battery, isolated casemates and turrets, for the second caliber guns, are used in combination. In the choice of a caliber for second caliber guns, 8-in. guns and 6-in. guns divide honors. In the Vittorio Emanuele

TABLE COMPARING BATTLESHIP DESIGNS.

	Virginia.	Duncan.	Borodino.	Mikasa.	Wittelsbach.	Vittorio Emanuele.	Type design.
Laid down	1901	1899-00	1900	1899	1899-00	—	—
Length between perpendiculars	435′	405′	397′	400′	418′	435′	435′
Breadth, moulded	76′ 10″	75′ 6″	76′ 0″	76′ 0″	68′ 0″	73′ 6″	76′ 0″
Draught, mean	24′ 0″	26′ 6″	26′ 0″	27′ 2″	25′ 0″	25′ 7″	—
Displacement, in tons	14,950	14,000	13,600	15,200	11,800	12,624	—
Indicated H.P. with forced draft	19,000	18,000	16,000	15,000	15,000	19,000	—
Speed, in knots, with forced draft	19.0	19.0	18.0	18.0	19.0	22.0	18.0
Boilers	Various.	Belleville.	Belleville.	Belleville.	Cyl.-Schz.	—	—
Armament:							
Main battery	4-12″	4-12″	4-12″	4-10″	4-9.4″	2-12″	4-9.4″
	8-8″	12-6″	12-6″	14-6″	18-6″	12-8″	12-6″
	12-6″	—	—	R. F.	R. F.	—	—
Secondary battery	12-3″	12-12 pdrs.	20-12 pdrs.	20-12 pdrs.	12-3.5″	12-3″	12-12 pdrs.
	8-3 pdrs.	6-3 pdrs.	20-3 pdrs.	8-3 pdrs.	12-1 pdrs.	12-1.8″	6-3 pdrs.
	8-1 pdrs.	—	4 Maxim.	4-2½″	—	—	—
Torpedo tubes:							
Above water	—	—	4	—	1	4	—
Submerged	2	4	2	4	5	—	2
Protective deck:							
Thickness of slopes	3″	1″	2½″	2″	3″	4″	3″
Thickness of horizontal parts	1½″	2″	1½″	—	1½″	2″	1½″
Armor:							
Length of water-line belt	Full.	⅔ lgth.	Full.	Full.	Full.	Full.	⅔ lgth.
Breadth of water-line belt	8′ 0″	7′ 0″	6′ 6″	7′ 9″	7′ 0″	—	7′ 0″
Thickness of water-line belt at amidships	11.8″	7″	8″	9″	8.8″	9¾″	7″
Thickness of water-line belt at ends	4″	2″	5¾″	4″	4″	4″	2″
Bulkheads	6″	7″	—	6″	6″	6″	6″
Length of upper belt	⅔ lgth.	⅔ lgth.	Full.	⅔ lgth.	¼ lgth.	⅓ lgth.	¼ lgth.
Width of upper belt	—	7′ 0″	5′ 6″	7′ 6″	7′ 6″	7′ 6″	7′ 6″
Thickness of upper belt	6″	7″	6.4″	6″	6″	6″	6″
Protection, largest guns	10″	11″	10″	14″	10″	8″	8″
Protection, medium calibre guns	6″	6″	6″	6″	6″	6″	6″
Protection, other guns	2″	—	3″	—	—	—	—
Conning tower, forward	9″	12″	—	14″	10″	10″	9″
Conning tower, after	5″	3″	—	3″	6″	—	3″
Coal supply, normal	900	900	900	1,400	650	1,000	650
Coal supply, bunkers full	1,900	2,000	1,500	2,000	1,250	2,000	1,250

the second caliber guns are 8-in. guns. In all the others, with the exception of the Virginia, the second caliber guns are 6-in. guns. In the Virginia both 8-in. and 6-in. guns are employed. The number of guns of second caliber varies from twelve 6-in. in the Duncan to twelve 6-in. and eight 8-in. in the Virginia. In the secondary battery also there is considerable variation in the number and caliber of the guns, the arrangement being dependent upon the system employed in mounting the second caliber guns. The caliber ranges from 15-pounders and 1-pounders in the Wittelsbach to 12-pounders and 3-pounders in the Duncan; and, in numbers, from forty in the Borodino to eighteen in the Duncan.

"In the matter of protection to stability by a water-line belt, a considerable range is noticeable. The lower limit is found in the Duncan, in which two-thirds of the length of the vessel is protected by a belt of a thickness of 7 in., the forward end being protected from the fire of secondary battery guns by 2-in. nickel steel plating riveted upon the skin plating—as in protective decks. The remaining five vessels under consideration have, for stability protection, complete water-line belts, the maximum thickness of which is found in the Virginia—11 in. at top of armor amidships, tapering to 8 in. at the bottom. The lower limit in the extent of the upper belt, affording protection to the ammunition supply for the battery, is found in the Wittelsbach, where this belt is limited to about one-fourth of the length of the vessel. Three of the vessels under consideration, namely, the Virginia, the Duncan, and the Mikasa, carry this upper belt over about two-thirds of the length. The Vittorio Emanuele has an upper belt over somewhat more than one-third its length, and the Borodino for the whole length. It should be mentioned, however, that in the Borodino both the water-line belt and this upper belt are so narrow that the two combined really make a wide water-line belt over the whole length of the vessel. The thickness of the armor employed for this upper belt is uniformly 6 in., except in the case of the Duncan, in which the water-line belt and upper belt are continuous and 7-in. armor is employed.

"In the character and extent of the protection to the guns of first caliber, the greatest range is noticeable. The lower limit of such protection is found in the Vittorio Emanuele, where 8-in. armor is employed, and restricted armored tubes with walls of equal thickness, for protection to the ammunition supply. From this the degree of protection ranges upward, the maximum being found in the Mikasa, in which there are barbettes 14 in. in thickness extending at their full diameter to the top of the water-line belt. The protection adopted for the guns of second caliber is uniformly 6-in. armor throughout all the designs under consideration. The method of disposing this armor for the protection of the guns varies. In three of the six ships there are central batteries, concentrated in the Wittelsbach and extended in the Virginia and Mikasa. In addition to this central battery the Wittelsbach and Mikasa employ, also, isolated casemates with 6-in. armor for a portion of the guns of second caliber; and, in the Duncan, this system of protection exclusively is employed for the second caliber guns. Upon the Vittorio Emanuele and Borodino, the second caliber guns are all carried in armored turrets, with 6-in. armor, and, in the Wittelsbach and Virginia, such turrets are combined with central batteries, or with central batteries and casemates. The exceptional features in protection and system of mounting in the superposition of 8-in. turrets upon 12-in. turrets in the Virginia, has been the subject of so much discussion as to make special comment unnecessary. The Borodino and Virginia are the only vessels in which any protection is provided for guns of the secondary battery.

"The speed adopted for two of the vessels is 18 knots. In the Virginia, Duncan and Wittelsbach, the designed speed is 19 knots. In the Vittorio Emanuele the speed feature is developed to an extent which separates this vessel widely from the others under consideration. Her speed of 22 knots, if realizable, would practically place her on an equal footing, as to speed, with the armored cruisers being constructed by several of the naval powers. There seems reason to doubt the accuracy of report as to the speed feature of this vessel, regard being given to the other features proposed.

"The lower limit in the coal supply in the designed condition is found in the Wittelsbach, the design of which provides for a normal supply of 650 tons, with a maximum stowage capacity of 1,250 tons. From this the normal coal supply ranges through 900 tons for the Borodino, Virginia and Duncan, 1,000 tons for Vittorio Emanuele, to a maximum for this element of 1,400 tons in the Mikasa.

"The variations which have been pointed out make direct comparison of the several vessels difficult. To establish a basis for the present comparison, it is proposed to assume a vessel whose dimensions are those of the largest vessel under consideration, in which the features of armament, protection, speed, and coal supply embodied are the minima of these several features, which may be found among the designs under discussion. Such a vessel would represent the extreme limit to which, as judged from current practice, it is thought possible to reduce the several elements, and will be designated a type design. This type design will then be a vessel of about 435 ft. in length and 76 ft. in breadth (about the extreme dimensions of the Virginia class), having a speed of 18 knots (the speed of the Mikasa and Borodino); with a normal coal supply of 650 tons (that of the Wittelsbach); a battery of four 9.4-in. guns (the first caliber battery of the Wittelsbach), and twelve 6-in. guns, twelve 12-pounder and six 3-pounder guns (the second caliber guns and secondary battery of the Duncan); two torpedo tubes (as in the Virginia); a water-line belt 7 in. thick and 7 ft. wide, extending from the after barbette for two-thirds of the length of the vessel, with 2-in. nickel steel plating carried from the forward end of this belt to the stem (the water-line protection of the Duncan); surmounted by a shorter belt 6 in. in thickness, enclosed by bulkheads at its ends of the same thickness, extending up to the top of the gun deck to form a protected battery (as on the Wittelsbach); the 9.4-in. guns and ammunition supply protected by barbettes and ammunition tubes, carrying armor 8-in. in thickness (the protection of the first caliber guns of the Vittorio Emanuele); and the 6-in. guns and ammunition supply protected by 6-in. armor (the protection of the second caliber guns provided in all of the designs under consideration). It has been necessary to assume that the protective decks in the several designs under consideration are of practically equal value as protection, and that the type design has an equivalent protective deck. Detailed data relative to the several features of this type design will be found in the last column of the foregoing table.

"To attempt to express in figures an absolute or relative naval value, even for vessels of the same class, is generally regarded as almost impracticable, because of the impossibility of suitably assigning values among the several design elements, all contributing to a successful whole and differing so widely in their indivdual purposes as to be practically incomparable. Since, however, such an expression of value, even if only very approximately correct, affords a means of giving point to a comparison, an effort will be made to reduce the present comparison to such terms as will permit the assignment of approximate relative values. The results, depending as they do upon so many things which, at best, can be but inaccurately known to any but the designer of each vessel, must, of course, be regarded as qualified by the inaccuracies in the data upon which such results depend. It may fairly be assumed that the naval value of any vessel at a given period depends chiefly upon the battery carried; the protection given to stability, armament, ammunition supply and personnel; the speed; and the time during which she may operate without interruption, as measured by her coal supply. Her naval value, therefore, is independent of her displacement, although there is a relation between that naval value and displacement which fixes the limit of naval value which may be reached upon any displacement, and the excellence of any design should be judged by the nearness of the approach of that design to this limiting relation.

"Such a vessel as the type design outlined above has, for naval purposes, a definite value, which might be expressed in a variety of ways. Each of the several vessels whose designs it is proposed to compare may be regarded as being such a vessel as the type design, upon which improvements of value have been introduced in one or more of the elements of armament, protection, speed, or coal supply. The designers of the several vessels under consideration, having provided for the minima of the several

essential features of battleship design, have varied the distribution of the remaining disposable weight in a manner which each individually deemed most efficient. Since each of the several features may be found developed to an extreme in some one or more of the vessels being compared, and since the one restricting and governing condition in such development is weight, may it not fairly be assumed that the naval value, assignable to the excessive development of any one of the design features, may be represented by the weight necessary to such a development in any degree above that represented by a minimum embodied in all the designs. Such an assumption will here be made; and the naval value of the type design will be assumed to be 4,300, the approximate weight required, under the conditions outlined, to provide in the type design the features embodied. The relative naval value of each vessel under consideration, as compared with the type design, will be expressed finally by adding to 4,300, the naval value of the type design, the weight which it would be necessary to add to the type design in order to provide in that vessel for the armament, armor, speed, and coal carried in the design whose relative naval value it is desired to represent. The several vessels, when compared with the type design, show increases in the several naval features, with corresponding added naval value as follows:

VIRGINIA.

Four 12-in. guns instead of four 9.4-in. guns	Value	160
Eight 8-in. guns additional	"	350
Twelve 14-pounders instead of twelve 12-pounders, and two 3-pounders and eight 1-pounders additional	"	40
Heavier and more extended water-line protection (11-in. armor as compared with 7-in. armor amidship)	"	410
More extended upper belt	"	120
Heavy guns in turrets protected by 10-in. armor; large diameter barbettes with 10-in. armor	"	620
Protection of 8-in. gun positions, and extended central battery protection	"	240
Protection to portion of secondary battery	"	40
Additional normal coal supply	"	250
One knot more speed, which, with weights added above, necessitates increase in machinery weights	"	520
Total additional value		2750
Value of type design		4300
Relative naval value		7050

DUNCAN.

Four 12-in. guns instead of four 9.4-in. guns	Value	160
Two additional submerged torpedo tubes	"	20
More extended upper belt of greater thickness	"	350
Heavy guns mounted on turn-tables with barbettes protected by 11-in. armor	"	500
All second caliber guns in isolated armored casemates, affording additional protection to such guns	"	260
Additional normal coal supply	"	250
One knot more speed, which, with the weights added above, necessitates increase in machinery weights	"	450
Total additional value		2000
Value of type design		4300
Relative naval value		6300

BORODINO.

Four 12-in. guns instead of four 9.4-in. guns	Value	160
Eight additional 12-pounders and fourteen additional 3-pounders	"	50
Four additional above water torpedo tubes	"	30
Heavier and more extended water-line protection (9-in. armor as compared with 7-in. armor amidship)	"	100
More extended upper belt, complete	"	200
Heavy guns in turrets protected by 10-in. armor with large armored tubes	"	450
Protection to portion of secondary battery	"	120
Additional normal coal supply	"	250
With same speed, weights added necessitate increase in machinery weights	"	130
Total additional value		1490
Value of type design		4300
Relative naval value		5790

MIKASA.

Four 10-in. guns instead of four 9.4-in. guns	Value	50
Two additional 6-in. guns	"	50
Eight additional 12-pounders, two additional 3-pounders, and four additional 2½-pounders	"	20
Two additional submerged torpedo tubes	"	20
Heavier and more extended water-line protection (9-in. armor as compared with 7-in. armor amidship)	"	350
More extended upper belt	"	190
Heavy guns mounted on protected turn-tables, with large diameter barbettes protected by 14-in. armor	"	580
More extended central battery and protection to two additional 6-in. guns	"	190
Additional normal coal supply	"	750
With same speed, weights added above necessitate increase in machinery weights	"	230
Total additional value		2430
Value of type design		4300
Relative naval value		6730

WITTELSBACH.

Six additional 6-in. guns	Value	145
15-pounders instead of 12-pounders	"	10
Additional torpedo outfit	"	25
Heavier and more extended water-line protection (8.8-in. armor as compared with 7-in. armor amidship)	Value	130
Additional protection to heavy guns (10-in. armor as compared with 8-in. armor)	"	80
Armored casemate for two additional 6-in. guns and turrets for four additional 6-in. guns	"	240
One knot more speed, which, with weights added above, necessitate increase in machinery weights	"	330
Total additional value		960
Value of type design		4300
Relative naval value		5260

VITTORIO EMANUELE.

Two 12-in. guns instead of four 9.4-in. guns	Value	50
Twelve 8-in. guns instead of twelve 6-in. guns	"	220
Twelve 14-pounders instead of twelve 12-pounders, and six additional 3-pounders	"	20
Additional torpedo outfit	"	30
Heavier and more extended water-line protection (9¾-in. armor as compared with 7-in. armor amidship)	"	270
More extended upper belt	"	80
Protection to second caliber guns by turrets	"	160
Additional normal coal supply	"	350
Four knots more speed, which, with weights added above, necessitate increase in machinery weights	"	1500
Total additional value		2260
Value of type design		4300
Relative naval value		6560

"It should be noticed that there is reason to believe that the figures for the indicated horse power and displacement for the Italian vessel, Vittorio Emanuele, are inaccurate, since, in the present state of ship building art, it would seem to be impracticable to procure, with the horse power given, the designed speed of 22 knots in a vessel of the designed displacement of 12,624 tons; and this displacement would seem to be inconsistent with the features which, if report relative to this vessel be true, it is proposed to embody in the design. It should also be noticed that the feature of protection given by the protective decks of the several vessels is regarded as being of equal efficiency and value in all the vessels. It is known that in the Borodino this protective feature has been developed to an extent somewhat in excess of that found in the other vessels compared; and, had it been practicable to extend the comparison to include this feature, the Borodino would, doubtlessly, have shown to better advantage in the final results.

"Since the relative naval values given above are expressed in terms of, mathematically, the same dimensions as those employed in the expression of displacement—if the relative naval values be divided by the designed displacements of the several vessels, the results may be expressed as a percentage, which might be termed the efficiencies of the several designs. These figures vary from 42.7 per cent. for the Borodino, up to 52 per cent. in the Vittorio Emanuele (assuming the designed displacement given for this vessel to be a possible one); and the order of merit of the designs would be, on this basis, as follows: Vittorio Emanuele, 52.0; Virginia, 47.2; Duncan, 45.0; Wittelsbach, 44.6; Mikasa, 44.3; Borodino, 42.7.

"In conclusion, it may be stated that while reasonable care has been given to the estimates upon which they are based, detailed accuracy in the figures given above is not claimed. The purpose has been to roughly estimate and express in concrete terms the relative naval values of the several vessels whose designs were considered, in order that the results of this comparison might be presented in a form more tangible than that of a general discussion of the several features of the designs."

DISCUSSION UPON CONSTRUCTOR GILLMOR'S PAPER.

Discussion upon Mr. Gillmor's paper, as might be expected, was both interesting and extended. At the suggestion of Mr. McFarland, presiding, Rear Admiral Bowles opened the discussion. The admiral said that the paper was simple and interesting, embracing purely the naval architect's point of view and being free from confusing details of arc of fire and muzzle energy.

"There is one peculiarity of comparison of battleship designs," said the admiral. "Wherever they originate the local battleship is made out to be the best. Possibly not sufficient attention has been paid in this paper to the feature of protective deck. The English vessels really carry a double protective deck. It will be found that the foreign design gives greater value to protection. The result of the present tendency will be that battleships will increase in size and I want to assure the society that, whether majority or minority plans prevail, the United States battleship will have no superior in any navy."

Capt. Von Rebeur Paschwitz of the German navy was called upon for his opinion upon the German design, but he pleaded that having spent the past five years of his life in the United States he was more qualified to speak upon the American design than the German. The thing which impressed him most was the enormous amount of coal an American ship could carry. He was surprised to hear Admiral Bowles say that the size of the battleships would increase, as he thought the depth of the United States harbors limited the draught.

Capt. P. E. Tchernigovsky of the Imperial Russian navy ventured to remark that personnel had a great deal to do with the effectiveness of the ship.

Lieut. L. H. Chandler of the torpedo boat service said that, while the paper was important, no satisfying conclusion could be reached which did not take in arcs of fire and muzzle velocity. Under this comparison a ship which shows very highly might be put out of action by a really inefficient ship.

Lieut. Com'dr White feared that the paper compared ships for what they apparently are. "The Virginia," said he, "has an open deck. The Duncan's 6-in. guns are in closed casemates, each casemate having its own source of ammunition supply. Our later battleships are deficient in this respect. Our guns and guns' crews are subjected even to the fire of secondary guns. The same is true even of our turrets. Turrets could be con-

structed so that the men would not be exposed. As to the superposed turrets it may be calculated that 25 per cent. of the shots aimed at the 13-in. turret would hit the 8-in. turret above it. Moreover the conspicuous character of the double turret would make it the main target for the guns of the other ships. Turrets should be as inconspicuous as possible. A great deal depends in action upon the facility with which the guns may be handled and fired. Lighter guns can produce so rapid a fire as to wipe out the heavier guns. I think we are not warranted in handicapping our ships with 8-in. guns."

Rear Admiral Bowles answered Capt. Von Rebeur Paschwitz's question as to draught. He admitted that the depth of harbor did limit the size of the battleship but that he had come to the view of a distinguished civil engineer who held that while God had made the harbors man can re-make them. As battleships are the chief defenses of the nation the department will continue to develop them to their highest efficiency.

Mr. George Crouse Cook inquired why torpedo boats had not been included in the comparison and Lieut. Chandler replied that there was little doing here or abroad in torpedo boat construction.

CHANGES IN TORPEDO BOAT DESIGNS.

MR. CHARLES P. WETHERBEE, OF THE BATH IRON WORKS, SUCCEEDS IN STIRRING UP A GREAT DEAL OF DISCUSSION WITH HIS PAPER.

Mr. Charles P. Wetherbee's paper upon "Changes in Torpedo Boat Designs," was written for the purpose of eliciting discussion upon it—an object which, owing to its radical nature, it succeeded admirably in doing. In its opening pages it dealt with the progressive trial of the torpedo boat Biddle, which will be passed over briefly for the reason that while interesting it was not the real meat of the paper. He said that modern torpedo boats have displacements ranging from 50 to 300 tons, with indicated horse powers varying from 700 to 6,000. Destroyers range from 300 to 475 tons with from 4,500 to 8,500 I.H.P. Both torpedo boats and destroyers have models with a ratio of length to beam varying from 10.5 to 9.67 and the ratio of depth to beam is .65 and .75. The coefficient of fineness varies from .38 to .48. The author related an interesting point in the trials of the Biddle and the Barney as showing the influence of a foul bottom upon speed. The Barney had been lying for weeks in the water until the paint on her bottom was blistered. While the Biddle, with her clean bottom, made 29 knots with 3,910 revolutions, the Barney made only 27 knots with 3,960 revolutions. Mr. Wetherbee then came to the gist of his subject. He said that the existing type of torpedo boat is a smooth-water vessel and should be used only for harbor defense. Continuing, he said:

MR. CHAS. P. WETHERBEE.

"If these vessels are to be sent to sea, a radical change in model is necessary. A vessel with a ratio of length to beam of 10 to 1, having the comparatively small dimensions of a torpedo boat or destroyer, cannot be considered of a seaworthy model, nor is it one that can be made sufficiently strong to go to sea in bad weather. Additional material worked into the long shallow hull does not strengthen in proportion to the weight added. The result of this addition is simply a great reduction in speed for only a slight increase in strength, while the seaworthiness of the model is as poor as before. The dead wood aft is usually cut away to give a smaller tactical diameter. On this account the vessel will not steer in a seaway at low speed. If the speed is increased sufficiently to steer, the shocks of the sea become too great for the strength of the hull. Even neglecting the question of increased strength, it is doubtful whether a faster boat would not be obtained by decreasing the ratio of length to beam. The model that shows the least resistance in the tank is not necessarily the one which will give the greatest speed when built into a boat, because the shape may be such as to require an abnormally heavy hull to get even the small strength necessary for smooth-water work. All saving in machinery weight due to using a model requiring small power for a given speed, is more than offset by this extra hull weight, the result being that a model less efficient from a propulsive point of view, but having a lighter hull, goes faster.

"The writer is familiar with two types of boat built to fulfill absolutely the same programme. One has a ratio of length to beam of 10½; the other has a ratio of 9 2-3. The tank shows that the smaller ratio gives a loss in speed of nearly 7 per cent. for the same indicated horse power at the same displacement. The latter boat, however, when built, owing to a smaller ratio of length to beam, had a considerably lighter hull with the same strength as the former, and was enabled to carry a greater trial load; and, in addition, to carry enough extra horse power not only to make up this handicap of model, but to actually give three knots more speed and still have about 20 tons less displacement than the boat with the 10½ to 1 ratio. It is not fair, however, to credit the model with the entire difference between these boats, but a large amount is certainly due to it. It is probable that this ratio of length to beam (9 2-3) could be reduced even more with an advantage in speed; certainly there is no doubt but that it would make the vessel more seaworthy, and, except perhaps at the extreme speeds, more efficient from a propulsive point of view. At the reduced speeds at which the vessel is run nine-tenths of the time during her existence, the smaller ratio of length to beam is amply sufficient, and the reduced ratio of wetted surface to displacement is such that the indicated horse power for speeds where the skin resistance is a considerable part of the total resistance, would be less with the same displacement. This large ratio of wetted surface to displacement explains why the admiralty speed coefficient for these long lean boats never exceeds 200, even in conjunction with a fairly good propulsive coefficient. The model is finer than necessary for the speed where the maximum admiralty coefficient occurs.

"For small vessels designed to go to sea a ratio of length to beam of 8 to 1 is certainly none too small. This would probably cause a reduction of 25 per cent. in the smooth water speed, as compared with that of a model having a 10½ to 1 ratio at the same displacement. This disadvantage would entirely disappear in a seaway, and, in addition to having a hull better proportioned for strength, the vessel would be of a fit model to keep the sea in bad weather. The ratio of depth to beam (.66) at present in vogue should not be decreased. With the ratio of length to beam of 8 to 1, and the same depth to beam ratio which at present prevails, the present scantlings for vessels of the same beam will give a fairly strong hull, if means are adopted to make the longitudinal strength members, particularly the deck, capable of developing their full strength in compression without buckling. Unlike big ships, these small, high-powered vessels develop their greatest bending moment in sagging when the ends are supported on the crests of two adjacent waves with the middle in a hollow. The bending moment under these conditions for a vessel having a 10 to 1 ratio, is nearly three halves of that found when the conditions are reversed, and when the shock which results from jumping the vessel at high speed into a fairly heavy head sea is added to this bending moment, the compressive stresses in the upper longitudinal members are by far the largest that have to be taken into consideration. As the strength of the deck against buckling in compression depends upon the moment of inertia of the cross section and the modulus of elasticity of the steel, and not upon its compressive strength, the futility of the frequent attempts to increase the strength of this class of vessel by simply using stronger steel without increased scantlings, becomes apparent when it is remembered that the modulus of elasticity varies only 3 per cent. from twenty-nine millions throughout the range from the softest flange steel to the hardest tool steel.

"Another frequently-made mistake caused by this same constant value of the modulus of elasticity of all steel is the allowance in calculations of a fictitious thickness for stronger steels when used in conjunction with mild steel in tension, after which the augmented area so obtained is credited with the full strength of the weaker steel. This is wrong. The two classes of steel have the same modulus of elasticity and only offer resistance in proportion to their actual areas when subjected to stresses within their elasticity limits. What actually occurs is that the weaker steel in this combination passes its elastic limit first, thus throwing nearly the entire stress upon the remaining stronger steel with disastrous results. In order to obtain sufficient compressive strength in the deck, other means than the mere thickening of the plates must be resorted to if a respectable degree of lightness is to be retained. To this end, longitudinals of angle, bulb angle, or, wherever possible, of plate, should be worked under the deck not over two feet apart in a manner similar to that by which the bottom of the boat is reinforced, and a 1½-in. non-fireproofed wood deck thickly fastened to the steel is also of great advantage in preventing the deck plate from buckling, also solving the problem of giving a deck which offers a proper foothold in a seaway. The nearer the midship section of a vessel approaches a tube in shape, the stronger the vessel will be, and all longitudinal members are stronger in compression if given as much curve as possible in the athwartship direction. As great a crown of deck as is compatible with its use is desirable for this reason. Flat surfaces should be avoided everywhere. They are weak under all stresses except direct tension.

"In addition to the unsuitable model, the torpedo boats and destroyers of the United States navy possess some faults peculiar to themselves. They have too many useless fittings and attachments. Their machinery, through complication, is too liable to break down. Both hull and machinery have unnecessary weight devoted to the unimportant details that would serve better if expended on the vital parts. It is unfortunate that officers connected solely with torpedo boats and destroyers in each of our designing bureaus in Washington are not usually on duty there long enough to follow a design made by them through the various stages of construction to the completed vessel. The torpedo boat suffers more than large ships from this system. The lightness of touch and line of thought necessary to design and construct a successful torpedo boat are instantly lost if the same man has charge of large ship work at the same time. It would also be of advantage to the design of a torpedo boat as a whole if some one man of great experience with them could have the final decision concerning all matters entering into the design, no matter which bureau has cognizance of the same. Many articles now creep in that are unnecessary, and some things even are duplicated through being specified by two bureaus. This man should also be able to take a bird's eye view of the vessel as a whole, irrespective of department, and at the same time should be able to see in his mind's eye everything as it will finally be installed in each individual department.

"Space is very limited in these boats, and although each article in itself, as its drawing comes up for approval, does not look to be much, the combination of all the individual articles specified, drawn, and approved, one at a time, frequently presents great difficulties owing to lack of space, and, if installed, they are inaccessible. It is stated that a certain great ship yard in Europe has a high-salaried official whose sole duty it is to go over the ships built by that concern and make a list of what can be left off in future vessels. There is certainly a great field for him on board our torpedo boats and destroyers. The following should be omitted from the hull and equipment as being out of place on vessels of this class: Complicated drainage systems; W. T. magazines with their flooding, draining, lighting and ventilating apparatus for fixed ammunition; the entire system of bells, push buttons, and annunciators, with their accompanying wiring in conduit and distribution boxes; all voice pipes except from forward conning tower to engine rooms and to after conning tower; the system of wiring in conduit and the type of fixtures for the electric plant.

"In the steam engineering department of torpedo boats and destroyers there are too many units of all descriptions, too many compartments; in some cases, too many boilers and too many engines, too many cylinders to an engine, too many blowers, too much pipe, too many valves, and too many ways of doing each particular maneuver with the piping. The weights are pared too fine on the main engines, boilers and blowers, while the piping, valves, fittings, manifolds and other auxiliaries are no lighter than on any other class of ship. Pipes need not have the same allowance in thickness for wear as is given to a battleship as the vessels are shorter

lived. The engineer staff allotted to torpedo boats is far too small, as will be seen by comparing the number of men allowed with those assigned to any other naval vessel of the same horse power. This is unfortunate, for no other type of machinery deteriorates so rapidly from neglect or requires more expert supervision. With this small staff in view, everything should be made as simple as possible. As we have to admit once for all that these vessels are not fit for sea-going work, the evaporators and especially the distillers with their accompanying piping and pumps, should be dispensed with and be replaced by reserve feed-tanks. Ash ejectors with their piping are useless. Four-cylinder main engines take more care and room than those with three cylinders, besides using more steam for the same power. The same power is much more easily cared for and is lighter if generated in a small number of large boilers than in a large number of small ones. Almost no attention is paid to the economy of coal consumption. The prevailing idea that the lightest machinery can be obtained by making as light an engine as possible without regard to steam economy is erroneous, for the penalty is paid when it comes to the boilers. They are far heavier than would be necessary if a little more weight were devoted to the engines to obtain a more economical use of steam.

"The above faults are in all cases not errors in design, but they simply result from the fact that these things are inappropriate on a harbor defense torpedo boat, while they are absolutely necessary on a sea-going battleship. The solution of the so-called torpedo boat difficulties seems simple enough. The features criticised in our present boats are largely the outcome of the attempt to use the boats in a service for which the type was never originally intended. They must be restricted to harbor defence, and a new type more in the nature of a despatch boat must be designed for sea-going work. These new boats must be safe at sea in any weather, and the larger ones (from 400 to 600 tons) must be able to make good speed in anything short of the worst weather. Unlike the torpedo boat, which must be invisible above all things, these boats must have enough freeboard to make them seaworthy. They should have sufficient deadwood aft to make them hold their course at low speeds in bad weather, and if a small tactical diameter is deemed necessary, add a bow rudder to get it, especially in the single-screw boats. They must have a ratio of length to beam of at most 8 to 1, with a ratio of depth to beam of .7. Make the hulls amply strong and if the vessels are of 200 tons or under, use the composite construction instead of steel plating for shell and deck. After a strong, seaworthy hull and ample necessary equipment and ordnance are provided, I would turn my attention to getting as much simple reliable power into them as possible with the necessary coal and water. These vessels must have evaporators, but I do not regard distillers or ash ejectors as necessary.

"As to machinery, I should use a reliable type of bent tube watertube boiler and rugged three-cylinder triple-expansion engines throughout the class. The engine cylinder ratio should not exceed 5 to 1, as these boats will run most of the time at reduced power. I would never use two engines where one would do. Providing for emergencies in the way of break downs, by duplicating moving parts in the smaller class of boats, is more likely to be the cause of these same break downs. As boats having less than 1,000 H.P. will hardly be constructed for this service, we can neglect any powers up to that amount. The arrangements for powers above 1,000 would be 1,000 I.H.P. to 2,500 I.H.P., two boilers, single screw; 2,500 I.H.P. to 4,500 I.H.P., two boilers, twin screw; 4,500 I.H.P. to 8,500 I.H.P., four boilers, twin screw; 8,500 I.H.P. to 12,500 I.H.P., six boilers, triple screw.

"These powers are the forced draft power, and they could be maintained for only about four hours. The cruising power would be about half of the maximum. Triple screws are adopted for the larger powers, as their engines fit into boats of these dimensions better than large twin-screw engines, and at the same time the proper propeller area can be obtained without excessive draught of water. Simplicity should be the motto throughout the design, and nothing that can possibly be dispensed with should be incorporated into either hull of machinery. In conclusion, the writer wishes to acknowledge his indebtedness to many friends throughout the country who have supplied data. Particular thanks are due to the Bath Iron Works for access to their very complete torpedo boat data and for the great assistance afforded in the preparation of this paper. He is also under obligation to the bureau of construction and repair, and to Naval Constructor D. W. Taylor for the data obtained by towing the Biddle's model in the experimental tank."

A LIVELY DEBATE ON MR. WETHERBEE'S PAPER.

"That paper reminds me," said Mr. McFarland, when Mr. Wetherbee had finished reading, "of the Irishman at the Donnybrook fair. He is out for everything in sight."

"I don't believe it is expedient for me to be drawn into a general discussion of this subject," said Rear Admiral Bowles. "That is why I beg the privilege of speaking first. I want to express my satisfaction with Mr. Wetherbee's paper. It is timely, necessary and proper and reveals most intelligent hindsight from observations upon his own work. The criticisms which he has made are so uniformly severe upon all parts of the navy department that there can be no hard feeling. I wish, however, to express dissent from the basic design which he presents. Torpedo boats for harbor defence are useless; they must accompany the fleet. Harbor defence might do for the army but a naval vessel must go to sea, even those which we have."

Mr. W. D. Forbes thought that torpedo boats went wrong for two causes—either the design or the workmanship was bad. He added that it was quite evident that the designers had gone too far in lightness in the endeavor to attain tremendous speed.

Mr. H. A. Magoun was of the opinion that a great deal of unnecessary equipment found its way upon torpedo boats and cited the fact that torpedo boats contained 1,500 ft. of speaking tube at 1 lb. per foot, while in some instances the distances were so near that the men could almost touch each other.

Mr. John S. Hyde of the Bath Iron Works was called upon for his opinion but he said that Mr. Wetherbee had expressed his views even better than he could.

Lieut. A. P. Niblock said that there are seventeen distinct designs among the thirty boats in the United States navy. There has been a sad lack of uniformity of idea, for which no one person is particularly responsible.

Lieut. Chandler in the main agreed with Mr. Wetherbee. He thought that weight might first of all be taken out of the fittings and not out of the hull and machinery. In his experience on board torpedo boats he had frequently thought that the designers had given battleship fittings to the boat. He thought Mr. Wetherbee's expression "harbor defences" misleading, because the boats had to get out and it made little difference in a sea whether they were out one mile or fifty miles. He thought that construction which did very well in smooth water was not sufficient in rough water. Even hatches which are perfectly tight in smooth water are not so in a sea. He thought the boats should be made sea-going, even at the sacrifice of speed.

Naval Constructor J. H. Linnard said that in leaving out fittings there was a tendency to eliminate the other fellow's and put in some of your own.

Naval Constructor D. W. Taylor illustrated the wave movements of torpedo boats according to speed upon the blackboard. He was requested to reduce his drawings to ink and incorporate them as an addenda to Mr. Wetherbee's paper.

In his general reply, Mr. Wetherbee said that he did not intend to convey the impression that he desired boats built for harbor defence. What he thought was that the torpedo boat should be designed for sea-going service.

Mr. F. Merriam Wheeler indorsed in the main Mr. Wetherbee's paper. An adjournment was then taken until afternoon.

LATE DEVELOPMENTS IN ORDNANCE AND ARMOR.

AN EXHAUSTIVE AND IMPORTANT CONTRIBUTION TO THE SUBJECT BY MR. J. F. MEIGS, ORDNANCE ENGINEER—MUCH VALUABLE DATA AND OBSERVATION SUBMITTED.

At the concluding session on Friday afternoon Col. Edwin A. Stevens, vice-president of the society, presided. Mr. J. F. Meigs, ordnance engineer, read a paper upon the subject, "Late Developments in Ordnance and Armor." It was a most exhaustive review of the subject, set forth clearly and without any confusing details whatever. He said:

"In the past ten years the developments in armor plate have consisted in, first, the introduction of nickel in the armor; second, the adoption of the super-carbonizing process invented by Mr. Harvey; and third, the perfecting of this super-carbonizing process by Krupp. Parallel with these improvements in armor plate, whose tendency, or rather the tendency of the latter two, has been to produce armor of very hard outside face, the velocities of projectiles have advanced. From a purely rational point of view this would appear to be unreasonable, because hard armor is best attacked by heavy projectiles, which, if the size and weight of the gun remains constant, would mean a lowering of velocities. In other words, hard armor which may be cracked is best attacked by heavy projectiles, and comparatively soft armor by light, fast-flying shot. In the ten years under review the advance in the resisting power of armor has been very material. The advance made by the introduction of nickel and by the adoption of the Harvey surface-hardening process, which were brought in at about the same time, added probably quite 25 per cent. to the power of armor plate of fixed thickness to resist penetration. The adoption of the Krupp process probably added another 10 per cent. to the resisting power of armor plate, and also added very materially to its power to resist cracking. It is perhaps not too much to say that the armor of today has 40 or 50 per cent. more power to resist penetration than that of ten or twelve years ago of the same thickness. Its power to resist cracking is very difficult to measure numerically. This power, however, is very greatly increased, as much because of the better methods of melting and forging large masses of steel, as for any other reasons. It seems now almost impossible to crack well-made armor plates under conditions approaching those usual in reception tests. Their surfaces are spalled for an inch or two depth, and the tough back of the plate is very resisting to cracking effect. In a word, when comparing the armored ship of today with the ship armored twelve years ago, say, with the same thickness, we find the former has an enormous superiority.

"The same degree of superiority is not found in the gun itself. The guns of a fixed caliber are longer and heavier than they were, and the powder is better than it was ten years ago, but, as stated, the gun itself, though shaped differently, has not improved from improvement in quality of material so much as armor plate. Ten years ago a 6-in. gun weighed about 11,000 lbs., while now it weighs from 17,000 to 18,000. The former gun gave barely 2,000 ft. with the brown powder then in use, while the later gun, with its charge of smokeless powder, will give 3,000 ft. or more, and thereby its energy is more than doubled. This, however, it will be noted, is largely because the gun is heavier than the old 6-in. guns. The advantage which is most marked in the past decade in ship's guns, or, to use the more general term, in guns of position—that is, guns that are not moved from the place where they are set—is in rapidity of fire. Not many weeks since an English ship of war fired eight shots from a 6-in. gun in one minute, at a range of about 1,500 yards, at a target 15 ft. high, and struck it every time. Such a feat a few years since would have been thought impossible. We hear also of guns whose projectiles weigh 350 lbs. being fired three or four times a minute. These things are no doubt true, in at least a limited degree, and constitute a very marked advance in gunnery, for while it would not be possible to fire a 6-in. gun many minutes at eight rounds per minute, both because the crew would become exhausted and because the gun and other parts would heat, yet the fact that this can be done for a short time, when it becomes necessary, is a matter of great consequence.

"While, of course, it is very difficult to say at what range modern ships will fight, yet it would appear that this matter must be settled before any conclusions can be reached with regard to the kind of guns to be placed in ships. For example, if the old Pensacola, having ten smooth-bore 9-in. guns on her broadside, can choose her range, she is more than a match for the modern Atlanta, of equal tonnage, carrying three 6-in. and two 8-in. breech-loading guns on her broadside. The ship that can control range can outclass the other. I think that most naval officers believe that with their guns, and in reasonably smooth water, they can make fair practice at 3,000 or 4,000 yards. My own belief is that this is too great an estimate. At 3,000 yards range a target 15 ft. high, when a gun is rolling at an angular rate of one degree per second, which is a fair rate only, the prolongation of the line of sight of the gun would sweep

across the freeboard of a ship 15 ft. high, which would include all the vulnerable part of the ship, in somewhat less than one-tenth of a second. This is a period of time too small to be appreciated by a man's nerves, and, indeed, the accuracy of operation of the firing apparatus of the gun can hardly come within this limit.

"The naval officer has a certain weight to put into battery, and the question comes to him at once: Having 100 tons to dispose in guns and gun carriages, shall it be put in so many 8-in. guns or in so many 6-in. guns? Roughly, the weights of guns vary with the cube of the calibers, and for every 8-in. gun you can have eight 4-in. As the 4-in. gun fires a good deal faster than the 8-in., the weight of metal and of bursting charge thrown by the battery of light guns would considerably exceed that thrown by the heavier ones. The weight of a single discharge from a battery of fixed weight, of any caliber, would remain about the same, of course. These, it seems, are the great tactical questions in regard to guns: First, having a fixed system of guns—that is, having guns of differing calibers in which the dimensions are about proportional to the calibers—what size guns shall we use? and, second, there is the other question: Is the system right? That is, should 8-in. guns weigh what they do, or should they weigh more or less; or, to put it in another way, are we satisfied with present weights of guns, or do we want more velocity in a gun of fixed caliber, and are we willing to accept the increased weight that must be given to the gun to get this. Much discussion is going on now in regard to the substitution of 7-in. and 7.5-in. guns for 6-in. guns on the broadside of battleships, and while everybody must be desirous of increasing to the utmost the size of the guns, and consequently their destructive effect, it must be remembered that this inevitably makes the weight carried heavier, and in certain cases limits the speed of firing. It has been generally asserted that guns cease to be rapid-fire when increased beyond 6 in. in caliber. Even 6-in. guns must have their cartridges separate from the projectile, and, as the projectile weighs 100 lbs., it is about all that one man wants to put into a gun quickly when standing on the deck of a rolling ship.

"In no respect perhaps has greater improvement in gunnery been made in the last ten years than in the practically universal adoption of smokeless powder. At present, the pure nitro-cellulose powder is generally held to be much the best. Though smokelessness is usually put forward as the great advantage of the modern powder, yet the absence of solid residue in the products of combustion would appear to be the real gain in this regard. In the old powders about 40 per cent. of solid residue was projected from the gun as uselessly as though its weight was in sand, while in the modern powder all or nearly all the charge turns into gas and helps to propel the projectile. On the other hand, the gas of the modern powder, particularly where much nitro-glycerine is used in making it up, as is the case in cordite, for example, is of very high temperature and scores and gutters the gun very badly. This is much less so with the nitro-cellulose variety, and with the latter, where moderate pressures are used—say, of 34,000 or 35,000 lbs.—the scoring of the gun is not a very serious matter. The scoring of steel by hot powder gas is a most extraordinary phenomenon. If there is ever so little a channel through which the gas can escape the steel is washed out and disappears in a most wonderful way. As, however, the propelling power of powder depends upon the amount of gas given off and upon the temperature to which it is heated, it is desirable, of course, to use as high a temperature as we can. In other words, if the scoring and guttering of the gas could be controlled, the hotter it is the greater the velocity attained would be. As a matter of fact, however, when high pressures—say, 40,000 or 50,000 lbs.—are reached, the destructive power of the gas becomes very great. When the new powders came in first it was thought that a charge of one-fourth or one-third the weight of the projectile would be ample to give all the velocity that would be needed, but owing to the desire to attain very high velocities (3,000 ft. and upwards), the weights of charges have been creeping up of late until now, in some guns, they approach one-half the weight of the projectile, which is the figure at which they stood roughly in the days of brown or cocoa powder. It need hardly be pointed out here how important a matter this is as controlling the sizes of magazines of ships. Indeed, in some classes of artillery, as for instance in field artillery, where weight is of vital importance, there are many who believe that some form of nitro-glycerine powder may still be used, as it is with shoulder guns."

Mr. Meigs here devotes a paragraph or two to improvements in the quality of steel in guns, and continues:

"It used to be accepted as a sort of an axiom in ship design that the armor should be so distributed and the vulnerable parts of a ship so protected that no one shot could destroy her. This has led, in view of the heavy turret guns carried by ships, to the heavy side armor and heavy armor on the turret and barbette. I think a study of naval history will bear me out in the statement that the resistance of ships has been overcome nearly always by silencing the battery and not by destroying the ship. If this is so, a ship should carry large-bored guns of respectable penetrating and mine power, and their magazines and ammunition supply arrangements should be such that they could be served at maximum rate. Roughly, if the systems of the guns are the same—that is, if the guns are of the same dimensions, when stated in calibers—then for every 12-in. gun we may have twenty-seven 4-in. guns, and as the rate of fire of each 4-in. gun, owing to the size of which the ammunition could be handled at the gun (providing it could be brought there from the magazine) is quite five times that of the 12-in. it becomes apparent how much total metal and bursting charge is sacrificed for the heavy turret gun. Suppose a ship, instead of, say, four 12-in. guns and four 8-in. and sixteen 6-in. guns, should carry about 170 4-in. guns or eighty 4-in. on her broadside, or a total of fifty-six 6-in., say. Which would be the better ship? Of course this parallel may be reasonably combated, but to me it means a great deal. If it be true that ships are overcome by their batteries being silenced—that is, by their men being driven from the guns—then the number of shots fired becomes a question of great importance.

"At the present time it may be said that the principal guns of battleships are in turrets, usually in pairs, and are of 12-in. caliber. The thickness of the turret armor is 12 in. usually, or less. The so-called secondary batteries of battleships are composed of 6-in. guns, which are in broadside, and are often isolated by transverse armor and armor to their rears, which renders it unlikely that more than one of them could be silenced by the bursting of a single shell. These 6-in. guns are for the most part behind 5-in. and 6-in. armor. In other words, as the actual velocities for turret guns now afloat do not exceed an average of 2,300 ft., the turret guns of contending battleships can destroy each other only when within 600 or 700 yards range, and the guns of their secondary batteries, the ruling velocities of these being put at 2,300 or 2,400 ft., when within 1,000 yards range. More powerful guns of both classes are now being built and mounted, but a great number of 6-in. and 12-in. guns now in use would come within the approximate rule just laid down. Thus we may fix the fighting range of battleships at 1,000 yards. There appears to be no disposition to increase the caliber of the 12-in. turret guns forming the main battery of battleships, though there is considerable movement looking toward making these guns longer and heavier, and, consequently, imparting to their projectiles higher velocities than those now ruling. As respects the 6-in. guns forming the secondary batteries, naval opinion is entirely at variance. In this country there are many who would substitute for the 6-in. guns 8-in. guns, and others who would substitute 7-in. guns, while in England the bulk of opinion is in favor of a 7.5-in. gun, whose projectile weighs 200 lbs. To this 200-lb. projectile would be imparted a velocity of 3,000 or more feet, so that the 7.5-in. gun in England is a very large and very powerful weapon. The 7-in. gun proposed in this country requires a 160-lb. projectile, and to the projectile is imparted a velocity of 3,000 or more feet. There is some disposition on the continent of Europe to use lighter guns in turrets than those of 12-in. caliber, which will weigh from 45 to 50 tons; but in this country and in England the 12-in. gun seems to be pretty strongly held to. The secondary battery guns, however, as stated, are quite unsettled. Besides the 12-in. and 6-in. guns, protected, respectively, by 12-in. and 6-in. armor, battleships carry a large number of 3-in. 15-pounder guns, having a high velocity and having very little protection. The large armored cruisers, which, in their elements of offence and defence, now approach battleships very closely, carry somewhat smaller guns than the latter and their armor is accordingly reduced. When we come to the smaller vessels of all classes, the protection afforded the batteries is usually very little, besides the gun shields, and the side and other armor, of course, is also materially reduced.

"There are many reasons why the battleship, armed with 12-in. guns in her turrets and 8-in. guns on her broadsides, which is the favorite battery with those who would push the weight of battery very far, would have great advantages over battleships carrying only 6-in. guns in their secondary batteries; but, if the muzzle velocities of the 8-in. guns be equal to those of the 6-in. guns, and the total weights of battery are about the same, the number of 8-in. guns would be one-half that of the 6-in. and the rate of fire of the 8-in., as compared with the 6-in., will be very materially reduced—it is, perhaps, not too much to say that it will be reduced by one-half. The 6-in. gun can be man-handled—that is to say, the shot can be handled by one man and all operations performed with ease, without the use of mechanical apparatus. There are many devices for simplifying the handling of projectiles and getting them into the gun, but it must always remain that the weight of the 8-in. shot—now 250 lbs.—will be a serious impediment in the way of handling the gun rapidly.

"To summarize results it may be said that, in the past ten years, by the use of better mixtures, by improved heat treatment, and by very marked improvement in face hardening, the power of armor of a fixed thickness to resist penetration has been increased about 40 per cent., while its power to resist cracking has been increased in even greater degree. This has been taken advantage of in large measure in a reduction of the thickness of armor plate on a ship's side. The total weight of armor carried is not less than formerly, and indeed it is perhaps greater than it was, but it is more spread out, and, while the protection on the vital parts is as good and perhaps better than it was, there is now some weight in armor left to cover parts that formerly were without protection. Gun steel also—and in speaking of gun steel we may include the steel for shafting as well—has been materially improved in the period under review. The shafting steel now going into ships is very much stronger than that which was used ten years ago. It is, indeed, perhaps quite 70 or 80 per cent. stronger than the former material. The advance in gun steel has not been so marked, because ten years ago the purchasers of gun steel wanted an elastic strength of about 40,000 lbs., whereas only 28,000 or 30,000 lbs. was asked for in shafting. Now they both run 50,000 lbs. or even more.

"When we come to what may be called the tactical aspects of guns and armor, we find also material changes. The quality of the gun steel and of the armor, as is stated above, has advanced by perhaps 40 per cent., and full advantage has been taken of this in design. The modifications in design which have come about have been numerous. The armor is more distributed. It has come to be recognized that unprotected guns have no chance, and that 6-in. and 12-in. guns should be protected, respectively, by 6-in. and 12-in. armor. It should be noted that this means, if battleships are to penetrate each other, that ships must approach within 1,000 yards range in combat. This brings us back to the fighting range of old wooden ships, very nearly, for they had to approach within about 600 or 700 yards; and, when you consider that a battleship's 6-in. guns must have normal impact to perforate the armor protecting the 6-in. guns of their opponents at 800 or 1,000 yards, it may be said that the fighting range of ships has not so very materially altered in the past 100 years. What is here said may perhaps be combated, but, as 2,200 ft. velocity in a 6-in. projectile will not, even with normal impact, carry it through 6-in. armor, nor will 2,000 ft. carry a 12-in. projectile through 12-in. armor under like circumstances, it follows, when the vast preponderance of oblique impacts is considered, that ships must fight within 1,000 yards.

"Finally I want to bring forward, in order to more definitely determine the coming range of naval combat, the fact that there is one of its ruling factors which remains constant for all time. This is, the accuracy and delicacy of the firer's eyes and nerves. If a man can appreciate four intervals in a second, and if the firing apparatus put into his hands is instantaneous in action, he can hit a ship 15 ft. high, at a range of about 1,000 yards, when his own gun is swinging, in rolling, at an angular rate of one degree per second. Another important consideration is what is usually called the 'danger' space. With medium calibers, with 2,000 ft. velocity, the danger space is 1,100 yards. That is to say, the gun is independent of the range, as the trajectory is so nearly flat at that distance. The new guns now coming along, having 3,000 ft. velocity, have a greater danger space with existing targets, and are therefore independent of the range up to 1,300 or 1,400 yards. Whether it is better to use a 7-in. or 7.5-in. gun on the same weight as the 50-caliber 6-in. gun—that is, about 18,000 lbs.—in the secondary battery of battleships, is one of the pressing questions of the day. If the 7-in. or 7.5-in. gun has its weight increased pro-

portionately it will, of course, be better than the 6-in., except that its rate of fire will be less from the weight of its shot, but, if we take the larger calibered gun and accept a somewhat lower velocity, while using the heavier and larger shot and the same total weight in the gun and carriage, it may well be argued that the larger gun is the better. On the other hand, high velocity gives always an independence of the range at greater distances, and gives always greater penetration. The designer of naval ships is therefore on the horns of a dilemma with regard to the battery of the ship, as indeed he must be with regard to pretty much all of her elements, and he must be guided by judgment and by a careful balancing of conditions, so that, upon the whole, and in the circumstances most likely to occur, the ship he produces will be able to give a good account of herself."

RECENT EXPERIMENTS IN ATTACKING ARMOR WITH HIGH EXPLOSIVE SHELL.

The tenth paper was upon the subject "Recent Experiments in Attacking Armor With High Explosive Shell," by E. B. Babbitt, captain of ordnance, United States army. Discussion of this paper would of course be in order with the one that preceded it, Mr. Meigs' paper, regarding developments in ordnance and armor. Capt. Babbitt telegraphed his regrets that he could not read the paper in person. Secretary Washington L. Capps read it for him, prefacing it with the remark that it contained so much valuable information that the authority of the secretary of war had to be secured before it could be delivered. Space will very probably be found for this paper in a future issue of the Review.

Mr. John Fritz, who built the Bethlehem plant, was asked if he would discuss either Capt. Babbitt's or Mr. Meigs' paper.

"I can make armor but I can't talk about it," was the blunt comment.

Lieut. Com'dr White said that it was possible to keep the 6-in. gun trained on the target all the time, wherein lay its great advantage over heavier guns. He thought that all guns above 6-in. should have separate magazines and that the mechanical facilities to move the heavier guns by hand should be increased.

The last two papers were, "Some Notes on Tidal Corrections," by Col. Edwin A. Stevens, and "Side Launch of Torpedo Boats and Torpedo Boat Destroyers," by Assistant Naval Constructor W. G. Groesbeck. Both these papers will be discussed in the Review later.

Just before adjourning invitations were received from the Society of Mechanical Engineers to attend the unveiling of the statue of Robert Fulton in Trinity church, New York, on Dec. 5, and to attend the meeting of the German society of naval architects next spring.

Mr. W. H. Fletcher moved that the thanks of the society be given to Col. Edwin A. Stevens for offering the prize of $100 which brought out the two papers on balancing marine engines, but Col. Stevens held that no official information existed as to the donor of the prize and declined to entertain the motion. Invitations were received from Mr. George H. Barriss to inspect the steam pipe covering at the Manhattan power house and from the John N. Robins Co. to visit its yard where the American liner New York is now receiving a new stern.

INDUSTRIAL NOTES.

Solely on the merits of the Foster pressure regulator and kindred engineering specialties, the Foster Engineering Co. has outgrown its old quarters on Prospect street, Newark, N. J., and is now occupying a splendid new establishment at 107-113 Monroe street. The factory was built after the ideas of the management of the Foster company, and with an equipment of everything that is modern in machinery there is probably no better works of its kind anywhere. This company's valve is found in steering, hoisting, electric and other engines on steam vessels of all kinds —sea-going, coastwise and lake vessels, yachts, tugs, ferryboats, etc. It has been for years the standard reducing valve of the United States navy, orders being constantly on file for the equipment of battleships, monitors, cruisers, torpedo boats, destroyers, and other government vessels. Several foreign governments, recognizing their superiority, have installed them on vessels of war.

The New York Blower Co. of Bucyrus, O., has taken the contract for the largest order of ventilating blowers for marine purposes ever placed in the United States. These fans are to be built for the Eastern Ship Building Co., and will be installed on the large Pacific liners now building at New London for the Great Northern Steamship Co. There are fifty-two fans included in this order. Every ventilating blower on the ships is motor-driven, the motors being furnished by the Westinghouse Electric & Mnfg. Co.

A transportation company, recently organized in New York with a nominal capital of $25,000, has adopted the name New York & Caribbean Steamship Co. and proposes to operate between New York, Boston, Philadelphia, Baltimore, Newport News, New Orleans and the principal ports of Porto Rico. The directors are Ramon Cortado and William Cortado of Ponce, Porto Rico; Millard F. Prince of Bensonhurst, L. I.; William L. James of Brooklyn, and William H. Watt of New York city.

About $200,000 is to be spent in improvement of the works of the Stirling Co. at Barberton, O., where Niclausse water-tube boilers are made. In the marine department this company has orders ahead for two years, including boilers for ships being built by the Bath Iron Works, Eastern Ship Building Co., New London, Conn.; Wm. Cramp & Sons Ship & Engine Building Co., Philadelphia; Newport News Ship Building & Dry Dock Co., Newport News, Va.

Edwin S. Cramp has been elected vice-president of the Wm. Cramp & Sons Ship & Engine Building Co. of Philadelphia, to succeed his brother, the late Henry W. Cramp. Francis L. Potter has been elected a director to fill the vacancy in the board.

An excellent chart of Sandusky bay in colors has just been issued. It may be had from the Marine Review.

BELLEVILLE GENERATORS

Grand Prix 1889 Hors Concours 1900
Originated 1849 Latest Improvements 1896

Number of Nautical Miles made each year by Steamships of the Messageries Maritimes Co., Provided with Belleville Generators—Since their Adoption in the Service.

Year.	Australien	Polynésien	Armand Béhic	Ville de la Ciotat	Ernest Simons	Chili	Cordillère	Laos	Indus	Tonkin	Annam	Atlantique
1890.....	67,728	2,460										
1891.....	68,247	68,331	204									
1892.....	68,247	68,403	69,822	23,259								
1893.....	68,379	68,343	68,286	68,247								
1894.....	68,439	68,367	68,574	68,439	37,701							
1895.....	68,673	68,766	68,739	68,808	40,887	28,713						
1896.....	69,534	92,718	69,696	69,549	62,205	63,153	40,716					
1897.....	68,250	69,606	92,736	69,555	62,235	76,110	63,357	43,146				
1898.....	70,938	69,534	69,552	69,597	62,526	63,240	63,240	62,553	63,954	22,707		
1899.....	69,534	69,615	67,431	90,405	60,246	62,778	62,868	52,344	54,855	44,007	22,884	
1900.....	69,534	67,494	69,744	69,564	61,719	62,382	62,502	51,471	53,373	62,016	63,066	52,140
Total.....	757,503	713,637	644,784	597,423	387,519	356,376	292,683	209,514	172,182	128,730	85,950	52,140

ATELIERS ET CHANTIERS DE L'ERMITAGE, À ST. DENIS (SEINE), FRANCE.
WORKS AND YARDS OF L'ERMITAGE AT ST. DENIS (SEINE), FRANCE.
TELEGRAPHIC ADDRESS: BELLEVILLE, SAINT-DENIS-SUR-SEINE.

ITEMS OF GENERAL INTEREST.

Superintendent Partridge of the New York state department of public works has issued an order that all the canals of the state be closed for navigation at midnight, Saturday, Nov. 30, unless sooner closed by ice.

Ships of the Detroit & Cleveland Navigation Co., the large side-wheel liners operating between Detroit and Cleveland, and between Detroit and Mackinaw, will be laid up shortly. The last boat on the Lake Huron division leaves Detroit on the 25th inst. and the last boat between Cleveland and Detroit will leave Cleveland Dec. 10.

English journals announce that Sir Wm. H. White is about to resign his post as director of naval construction and assistant controller of the navy. He has rendered valuable service to the British government and has for many years been held in great respect in ship building circles throughout the world.

The steel steamers of the Northwestern Steamship Co.'s fleet, so-called Counselman boats, which made a trial during the past summer of direct trade between Chicago and Liverpool, are now on the Atlantic seaboard. James W. Elwell & Co. of 24 State street, New York, agents for the vessels, announce that two of them will be fitted up for the Texas oil trade and that the other two will trade between New York, Fernandina and Savannah.

A quarterly dividend of 1¾ per cent. was paid on the 20th inst. by the Great Lakes Towing Co., which controls the harbor tug business of the lakes. This company met with reverses on account of competition in its first year, but is now said to be in quite prosperous shape. It is thought that one of the dividends passed during the present year will be paid with the next quarterly dividend in February.

German liners are holding fast to the lead they have gained in fast trips on the Atlantic. The Kaiser Wilhelm der Grosse on her last westward voyage lowered her own record by fifty-eight minutes. She covered 3,052 miles from Cherbourg to New York in 5 days, 16 hours and 14 minutes, or at the rate of 22.41 knots an hour. Her old record was 5 days 17 hours and 12 minutes, and her best hourly average for a westward trip 22.33 knots. Every day throughout the voyage was hazy or cloudy, and the vessel was detained at Southampton thirty-six hours by fog.

The American Ship Building Co. is still taking orders for new vessels, although its capacity in the various yards around the lakes is taxed until July next. A contract was closed, a few days ago, with Mr. A. B. Wolvin of Duluth, representing the Provident Steamship Co., an organization evidently made up by Mr. Wolvin for the building of the vessel. The new vessel is to have over all length of 376 ft., keel 356 ft., beam 50 ft., depth of hold 28 ft. Engines will be triple-expansion with steam furnished by Babcock & Wilcox water-tube boilers. The ship will be built at West Superior.

Ship yards on the Atlantic seaboard are not booking as many orders for new merchant vessels as they were at this time a year ago, but of course still have a large amount of work ahead. A few orders have been reported recently. These include a ferry boat for the Central Railroad of New Jersey, referred to elsewhere in this issue, and which is to be built by the Harlan & Hollingsworth Co. of Wilmington, Del.; a tank steamer 360 ft. long and of 1,500,000 gallons capacity, to be built by the Cramps of Philadelphia for the Standard Oil Co.; a steam yacht to be built by Lewis Nixon of Elizabeth N. J., for Mrs. Andrew Carnegie and to be named Skibo Castle; a steam yacht of 21 miles speed for Hudson river service, to be built by the Gas Engine & Power Co. of Morris Heights, New York, for Mr. John D. Archbold of the Standard Oil Co.; a 185-ft. steam yacht to be built by the Gas Engine & Power Co. for Frank Jay Gould. Capt. Willard Thomas of Baltimore, general manager of the Baltimore, Chesapeake & Atlantic Ry. Co., has sent out specifications to ship builders and has asked for tenders on a steel passenger and freight steamer of 190 ft. length. It is expected that the vessel will cost about $100,000.

FUSIBLE BOILER PLUGS.

[Special correspondence to the Marine Review.]

Philadelphia, Nov. 20.—An echo of the fatal explosion on the City of Trenton has reached here in the shape of treasury department circular No. 98. It is from the office of the supervising inspector of steam vessels and deals with the composition of fusible plugs for marine boilers. The circular states that manufacturers of fusible plugs, whether boiler makers or others, will be required hereafter to stamp names thereon for identification, and to file with the local inspectors in the districts where their plugs are in most general use a certificate stating that the fusible plugs manufactured by them are filled with good Banca tin. Supervising and local inspectors are directed not to authorize hereafter the use of any fusible plug not stamped with the maker's name. They are also directed to see that the certificate referred to is on file. While the inquiry into the explosion of the City of Trenton's boiler was being prosecuted it was proved that some of the plugs then in service in boilers had for a core a composition which refused to fuse at a temperature of fully 800°F. The inspectors testified that they were ignorant of the metal employed and that they did not see that the plugs were placed in the crown sheets of new marine boilers of the locomotive type, in the position called for by the treasury regulations.

The British steamship Ormley, in command of Capt. Webber, sailed from Point Breeze this week with what is probably the largest cargo of oil in cases ever shipped to the Orient. Her destination is Hiogo, Japan, and she is laden with 157,871 cases, each case containing 10 gallons of refined petroleum. The value of the shipment is $146,030 and a full three weeks was required for its loading.

SHIP BUILDING AT WILMINGTON.

Wilmington, Del., Nov. 20.—The Harlan & Hollingsworth Co. has just contracted with the Central Railroad Company of New Jersey for a ferry boat in addition to the one now under way, this making the third vessel for the Central company this year. Another steamer for the Old Dominion line of New York was launched at the Harlan & Hollingsworth works Saturday and named Brandon. A distinguished party of officials of the steamship company witnessed the launch. The Brandon is a single-screw, steel freight and passenger steamer of the following dimensions: Length over all, 213 ft.; length from fore side of stem to after side of rudder post, 205 ft. 2½ in.; beam, molded, 37 ft.; width over guards, 43 ft.; depth, molded, 17 ft. 3 in. Her motive power consists of a triple-expansion engine with three cylinders, 18 in., 28 in., and 45 in. by 30 in. stroke, supplied with steam by two Scotch boilers, 12 ft. 9 in. diameter by 10 ft. 6 in. long and built to withstand a working pressure of 170 lbs. per square inch. The ship is built to class with the American Bureau of Shipping and with the United States Standard Register for coastwise service. The Brandon is the ninth vessel launched by the Harlan & Hollingsworth Co. this year. Orders still in hand, other than the two ferry boats above referred to, include a ferry boat for the Riverside & Fort Lee Ferry Co.; an auxiliary schooner yacht for Tams, Lemoine & Crane; tramp steamer Pathfinder for Messrs. Henry T. Knowlton and Amos D. Carver of New York, and two torpedo boat destroyers for the United States government.

The Marine Iron Works, station A, Chicago, have just issued a new 48-page catalogue descriptive of their product, which they will send free on receipt of request. A separate pamphlet issued by the same company, devoted especially to "River Navigation" (shallow water stern wheel boats), will also be included if asked for. 1

Excursion rates to Florida via Baltimore & Ohio R. R. and Washington, D. C., passing through the beautiful cities of the south. Stop over privilege allowed on all round trip tickets. Two fast trains leave Cleveland daily at 3:00 and 11:20 p. m. Call at city ticket office, 241 Superior street. tf.

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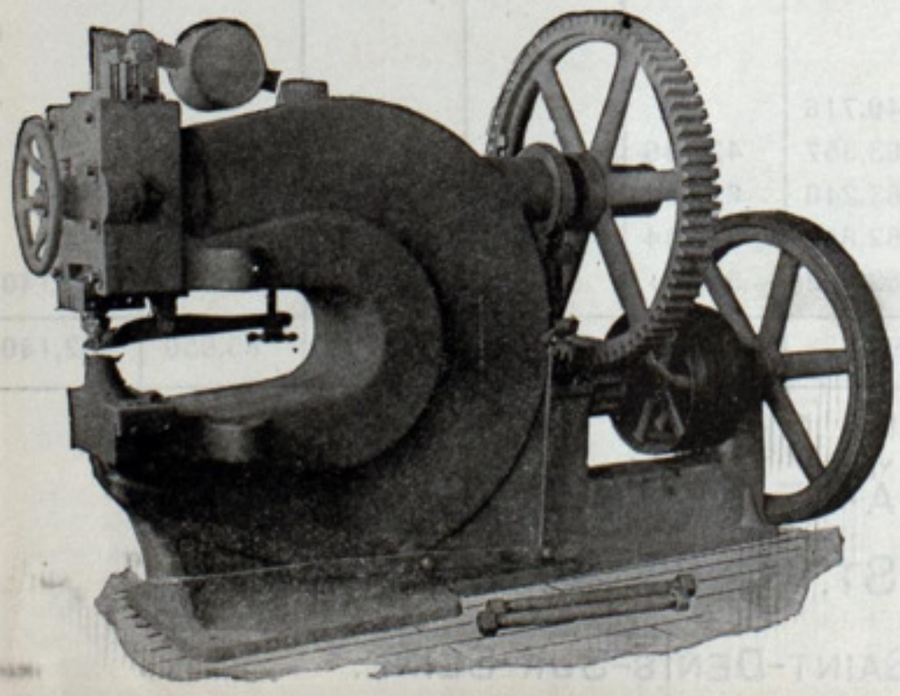
For navigation charts apply to the Marine Review.



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Length, 96.5 ft.; breadth, 18 ft.; depth, 7.6 ft.; 95 tons. In first-class condition. Price $5,000. E. J. Glackin, 363 So. Morgan street, Chicago. d

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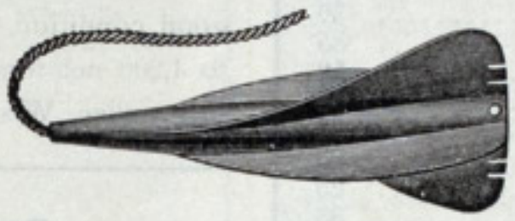

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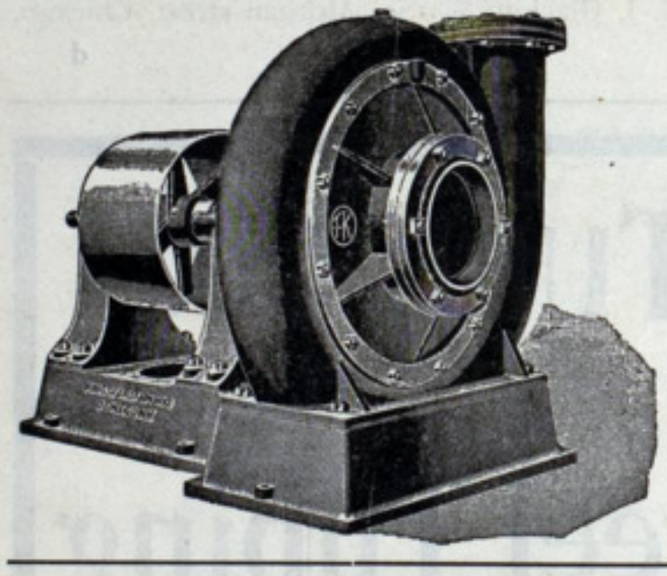

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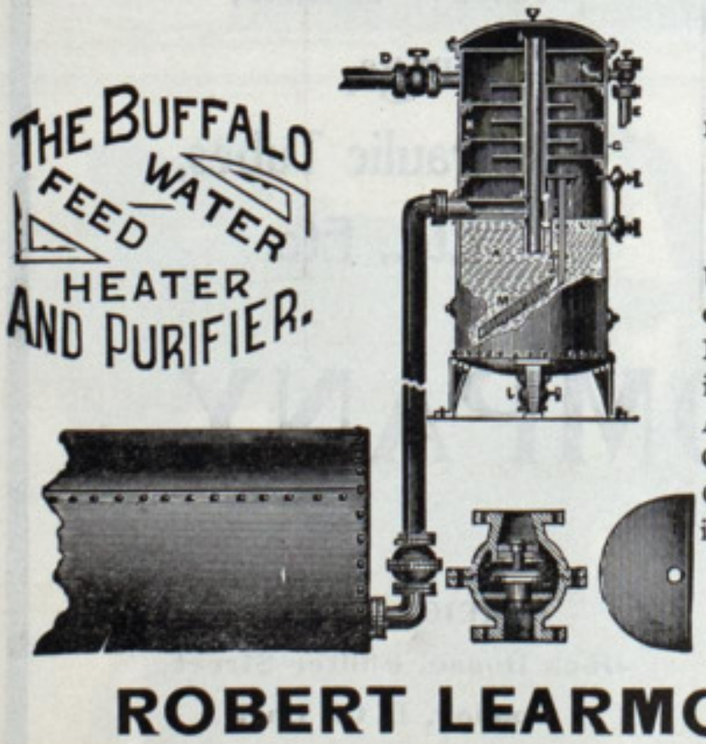

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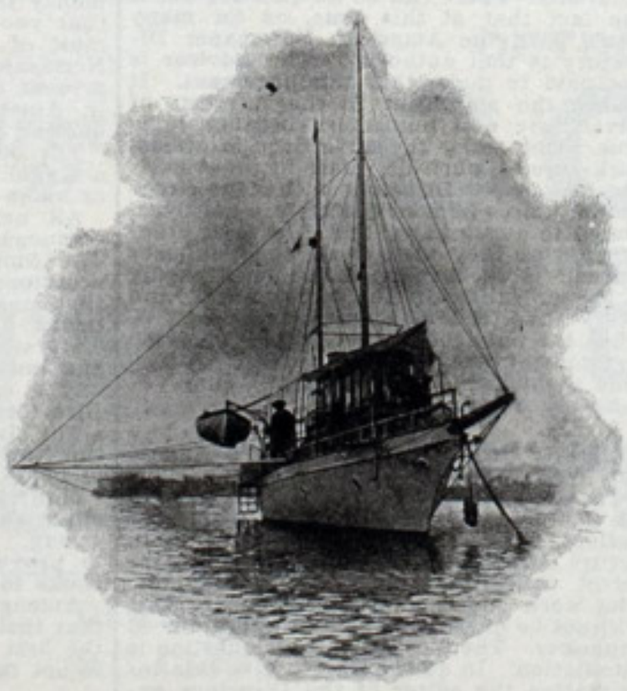

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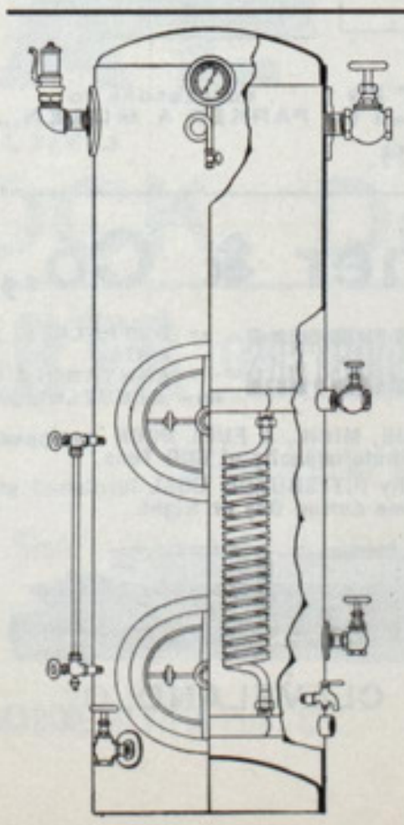

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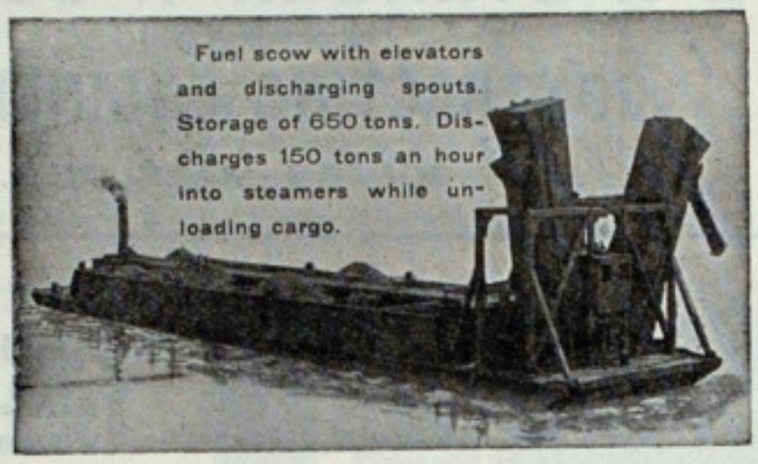

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MALLETS FOR CAULKERS, BOILER MAKERS, ETC.
N. Y. Mallet & Handle Works.....New York.

MARINE RAILWAYS, BUILDERS OF
Crandall & Son, H. I.....East Boston, Mass.

MATTRESSES, CUSHIONS, BEDDING.
Fogg, M. W.....New York.
Lein, Irvine & Co.....New York.

MECHANICAL DRAFT FOR BOILERS.
American Blower Co.....Detroit.
American Ship Building Co.....Cleveland.
Boston Blower Co.....Hyde Park, Mass.
Bloomsburg & Co., H.....Newport News, Va.
Buffalo Forge Co.....Buffalo.
Detroit Shipbuilding Co.....Detroit.
Sturtevant, B. F. Co.....Boston.

METALLIC PACKING.
Katzenstein, L. & Co.....New York.
U. S. Metallic Packing Co.....Philadelphia.

METALS FOR BEARINGS.
Cramp, Wm. & Sons.....Philadelphia.
Phosphor Bronze Smelting Co., Ltd.....Philadelphia.

METAL POLISH.
Bertram's Oil Polish Co.....Boston, Mass.

MILLING MACHINES OF ALL KINDS.
Bement, Miles & Co.....Philadelphia.
Niles Tool Works Co.....Hamilton, O.

NAUTICAL INSTRUMENTS.
Bliss, John & Co.....New York.
Ritchie, E. S. & Sons.....Brookline, Mass.

NAUTICAL SCHOOL.
Chicago Nautical School.....Chicago.

NAVAL ARCHITECTS.
Gaskin, Edward.....Buffalo.
Holmer & Goodenough.....New York
See, Horace.....New York.
Wood, W. J.....Chicago.

OAKUM.
Stratford Oakum Co., Geo.....Jersey City, N. J.

OILS AND LUBRICANTS.
Dixon Crucible Co., Joseph.....Jersey City, N. J.
Standard Oil Co.....Cleveland.

PACKING.
Crane Co.....Chicago.
Garlock Packing Co.....Palmyra, N. Y.
Jenkins Bros.....New York.
Katzenstein, L. & Co.....New York.
Sayen & Schultz.....Philadelphia.
U. S. Metallic Packing Co.....Philadelphia.

PAINTS.
Baker, Howard H. & Co.....Buffalo.
Toch Bros.....New York.
Upson-Walton Co.....Cleveland.

PATENT ATTORNEYS.
Thurston & Bates.....Cleveland.

PATTERN SHOP MACHINERY.
Atlantic Works, Inc.....Philadelphia.

PIPE THREADING AND CUTTING MACHINES.
Merrell Mnfg. Co.....Toledo, O.

PIPE, WROUGHT IRON.
Bourne-Fuller Co.....Cleveland.
Crane Co.....Chicago.

PLANERS OF ALL KINDS.
Bement, Miles & Co.....Philadelphia.
Niles Tool Works Co.....Hamilton, O.

PLANING MILL MACHINERY.
Atlantic Works, Inc.....Philadelphia.

PLATE BENDING AND PLANING MACHINES.
Bement, Miles & Co.....Philadelphia.
Cleveland Punch & Shear Works Co.....Cleveland.
Niles Tool Works Co.....Hamilton, O.
Wood & Co., R. D.....Philadelphia.

PLUMBING, MARINE.
Reilly Repair & Supply Co., James.....New York.
Sands, Alfred B. & Son.....New York.

PNEUMATIC TOOLS.
Standard Pneumatic Tool Co.....Chicago.

POLISH FOR METALS.
Bertram's Oil Polish Co.....Boston.

POWER DOORS AND HATCHES.
"Long Arm" System Co.....Cleveland.

PRESSURE REGULATORS.
D'Este Co., Julian.....Boston.

PROPELLER WHEELS.
American Ship Building Co.....Cleveland.
Atlantic Works.....East Boston, Mass.
Bath Iron Works, Ltd.....Bath, Me.
Cramp, Wm. & Sons.....Philadelphia.
Detroit Shipbuilding Co.....Detroit.
Farrar & Trefts.....Buffalo.
Fore River Ship & Engine Co.....Quincy, Mass.
Hardy, John B.....Tacoma, Wash.
Hyde Windlass Co.....Bath, Me.
Harlan & Hollingsworth Co.....Wilmington, Del.
Hodge, S. F. & Co.....Detroit.
Jenks Ship Building Co.....Port Huron, Mich.
Lockwood Mnfg. Co.....East Boston, Mass.
MacKinnon Mfg. Co.....Bay City, Mich.
Maryland Steel Co.....Sparrow's Point, Md.
Moran Bros. Co.....Seattle, Wash.
Neafie & Levy Ship & Engine Bldg. Co.....Philadelphia.
Newport News Ship Building Co.....Newport News, Va.
Nixon, Lewis.....Elizabeth, N. J.
Phosphor Bronze Smelting Co., Ltd.....Philadelphia.
Pusey & Jones Co.....Wilmington, Del.
Risdon Iron Works.....San Francisco.
Roelker, H. B.....New York.
Sheriffs Mnfg. Co.....Milwaukee.
Trigg, Wm. R. Co.....Richmond, Va.
Trout, H. G.....Buffalo.

PROJECTORS, ELECTRIC.
Badt-Goltz Engineering Co.....Chicago.
Elwell-Parker Electric Co.....Cleveland.
Fort Wayne Electric Works.....Fort Wayne, Ind.
General Electric Co.....Schenectady, N. Y.
Rushmore Dynamo Works.....Jersey City, N. J.
Seidler-Miner Electric Co.....Detroit.
Westinghouse Electric & Mnfg. Co.....Pittsburg.

PUMPS FOR VARIOUS PURPOSES.
Blake, Geo. F. Mnfg. Co.....New York.
Kingsford Foundry & Machine Works.....Oswego, N. Y.
Wood, R. D. & Co.....Philadelphia.
Worthington, Henry R.....New York.

PUNCHES, RIVETERS, SHEARS.
Bement, Miles & Co.....Philadelphia.
Cleveland Punch & Shear Works Co.....Cleveland.
Niles Tool Works Co.....Hamilton, O.
Wood, R. D. & Co.....Philadelphia.

REFRIGERATING MACHINERY.
Roelker, H. B.....New York.

REGISTER FOR CLASSIFICATION OF VESSELS.
Great Lakes Register.....Cleveland.

RELEASING HOOKS FOR DETACHING BOATS.
Standard Automatic Releasing Hook Co.....New York.

RIVETS, STEEL, FOR SHIPS AND BOILERS.
Bourne-Fuller Co.....Cleveland.
Champion Rivet Co.....Cleveland.

R. I. W. DAMP RESISTING PAINT.
Toch Bros.....New York.

RIGGING ROPE (WIRE).
American Steel & Wire Co.....Chicago.

RUBBER GOODS.
Hale Rubber Co., Alfred.....So. Boston, Mass.

RUBBER INSULATED WIRES.
Roebling's Sons, John A.....New York and Cleveland.
American Steel & Wire Co.....Chicago.

SAFETY VALVES.
American Steam Gauge Co.....Boston.
Ashton Valve Co.....Boston.
Crosby Steam Gage & Valve Co.....Boston.

SAIL MAKERS.
Baker, Howard H. & Co.....Buffalo.
Upson-Walton Co.....Cleveland.
Wilson & Silsby.....Boston.

SALVAGE COMPANIES.
See wrecking companies.

SEARCH LIGHTS.
Badt-Goltz Engineering Co.....Chicago.
Elwell-Parker Electric Co.....Cleveland.
Fort Wayne Electric Works.....Fort Wayne, Ind.
General Electric Co.....Schenectady, N. Y.
Rushmore Dynamo Works.....Jersey City, N. J.
Seidler-Miner Electric Co.....Detroit.
Westinghouse Electric & Mnfg. Co.....Pittsburg.

SHAPERS.
Bement, Miles & Co.....Philadelphia.
Niles Tool Works Co.....Hamilton, O.
Pratt & Whitney Co.....Hartford, Conn.

SHEARS.
See punches, riveters and shears.

SHIP AND BOILER PLATES AND SHAPES.
Bourne-Fuller Co.....Cleveland.

SHIP BUILDERS.
American Ship Building Co.....Cleveland.
Atlantic Works.....East Boston, Mass.
Bath Iron Works, Ltd.....Bath, Me.
Buffalo Dry Dock Co.....Buffalo.
Cramp, Wm. & Sons.....Philadelphia.
Craig Ship Building Co.....Toledo, O.
Chicago Ship Building Co.....Chicago.
Detroit Shipbuilding Co.....Detroit.
Fore River Ship & Engine Co.....Quincy, Mass.
Hardy, John B.....Tacoma, Wash.
Harlan & Hollingsworth Co.....Wilmington, Del.
Jenks Ship Building Co.....Port Huron, Mich.
Lockwood Mnfg. Co.....East Boston, Mass.
Maryland Steel Co.....Sparrow's Point, Md.
Moran Bros. Co.....Seattle, Wash.
Neafie & Levy Ship & Engine Bldg. Co.....Philadelphia.
Newport News Ship Building Co.....Newport News, Va.
Nixon, Lewis.....Elizabeth, N. J.
Pusey & Jones Co.....Wilmington, Del.
Risdon Iron Works.....San Francisco.
Roach's Ship Yard.....Chester, Pa.
Trigg, Wm. R. Co.....Richmond, Va.
Willard, Chas. P. & Co.....Chicago.

SHIP CHANDLERS.
Baker, Howard H. & Co.....Buffalo.
Moran Bros. Co.....Seattle, Wash.
Reilly Repair & Supply Co., James.....New York.
Upson-Walton Co.....Cleveland.

BUYERS' DIRECTORY OF THE MARINE TRADE.—Continued.

SOUNDING APPARATUS.
Farr, C. W.....Chicago.

SPARS—LARGE SIZES.
Moran Bros. Co.....Seattle, Wash.

STAYBOLTS, IRON OR STEEL, HOLLOW OR SOLID.
Falls Hollow Staybolt Co.....Cuyahoga Falls, O.

STEAM VESSEL FOR SALE.
Holmes, Samuel.....New York.

STEAMSHIP LINES, PASS. AND FREIGHT.
American Line.....New York.
Cleveland & Buffalo Transit Co.....Cleveland.
Clyde Line.....New York.
Dominion Line.....Boston.
Erie & Western Trans. Co.....Buffalo.
International Nav. Co.....Philadelphia.
Red Star Line.....New York.

STEEL CASTINGS.
Seaboard Steel Casting Co.....Chester, Pa.

STEERING APPARATUS.
American Ship Building Co.....Cleveland.
Chase Machine Co.....Cleveland.
Detroit Shipbuilding Co.....Detroit.
Electro-Dynamic Co.....Philadelphia.
Hyde Windlass Co.....Bath, Me.
Jenks Ship Building Co.....Port Huron, Mich.
Queen City Engineering Co.....Buffalo.
Sheriffs Mnfg. Co.....Milwaukee.

STOCKS, BONDS, SECURITIES.
Wright, Herbert & Co.....Cleveland.

STOCKLESS ANCHORS.
Baldt Anchor Co.....Chester, Pa.
International Anchor Co.....Cleveland.

SUBMARINE DIVING APPARATUS.
Hale Rubber Co., Alfred.....So. Boston, Mass.
Schrader's Son, A.....New York.

SURVEYORS, MARINE.
Holmer & Goodenough.....New York
Gaskin, Edward.....Buffalo.
See, Horace.....New York.
Wood, W. J.....Chicago.

TELEGRAPH—DECK AND ENGINE ROOM.
Cory, Chas. & Son.....New York.

TESTS OF MATERIAL.
Hunt, Robert W. & Co.....Chicago.
Pittsburgh Testing Laboratory, Ltd.....Pittsburg.

THERMOMETERS FOR MECHANICAL PURPOSES.
Helios-Upton Co.....Peabody, Mass.

TOOLS, METAL WORKING, FOR SHIP AND ENGINE WORKS.
Bement, Miles & Co.....Philadelphia.
Cleveland Punch & Shear Works Co.....Cleveland.
New Doty Mnfg. Co.....Janesville, Wis.
Niles Tool Works Co.....Hamilton, O.
Pond Machine Tool Co.....Plainfield, N. J.
Pratt & Whitney Co.....Hartford, Conn.
Standard Pneumatic Tool Co.....Chicago.
Watson-Stillman Co.....New York.
Wood, R. D. & Co.....Philadelphia.

TOOLS, WOOD WORKING.
Atlantic Works, Inc.....Philadelphia.

TOWING MACHINES.
American Ship Windlass Co.....Providence, R. I.
Chase Machine Co.....Cleveland.

TOWING COMPANIES.
Donnelly Salvage & Wrecking Co.....Kingston, Ont.
Midland Towing & Wrecking Co., Ltd.....Midland, Ont.
Swain Wrecking Co.....Detroit.

TRAPS, STEAM.
D'Este Co., Julian.....Boston.
Haines Co., Wm. S.....Philadelphia.

TRUCKS.
Boston & Lockport Block Co.....Boston.

TUBING, SEAMLESS.
Benedict & Burnham Mnfg. Co.....Waterbury, Conn.
Standard Seamless Tube Co.....Pittsburg.

VALVES, STEAM SPECIALTIES, ETC.
American Steam Gauge Co.....Boston.
Ashton Valve Co.....Boston.
Crane Co.....Chicago.
Crosby Steam Gage & Valve Co.....Boston.
D'Este Co., Julian.....Boston.
Jenkins Bros.....New York.
Wood & Co., R. D.....Philadelphia.

VARNISH PAINT.
Mair, John & Son.....Philadelphia.

VESSEL AND FREIGHT AGENTS.
Boland, John J.....Buffalo.
Brown & Co.....Buffalo.
Chamberlain & Co., S. R.....Chicago.
Drake & Maytham.....Buffalo.
Elphicke, C. W. & Co.....Chicago.
Hall & Root.....Buffalo.
Helm, D. T. & Co.....Duluth, Minn.
Holmes, Samuel.....New York.
Hutchinson & Co.....Cleveland.
Keith, J. G. & Co.....Chicago.
Kennedy Hunter & Co.....Antwerp.
Mitchell & Co.....Cleveland.
Richardson, W. C.....Cleveland.
Sullivan, D. & Co.....Chicago.
Tandy, Frank N.....Boston.

VENTILATING APPARATUS FOR SHIPS.
American Blower Co.....Detroit.
Boston Blower Co.....Hyde Park, Mass.
Buffalo Forge Co.....Buffalo.
Sturtevant, B. F. Co.....Boston.

WIRE ROPE AND WIRE ROPE FITTINGS.
American Steel & Wire Co.....Chicago.
Baker, H. H. & Co.....Buffalo.
Roebling's Sons, John A.....New York and Cleveland.
Upson-Walton Co.....Cleveland.

WHISTLES, STEAM.
American Steam Gauge Co.....Boston.
Ashton Valve Co.....Boston.
Crosby Steam Gage & Valve Co.....Boston.

WINDLASSES.
American Ship Windlass Co.....Providence, R. I.
American Ship Building Co.....Cleveland.
Hyde Windlass Co.....Bath, Me.
Jenks Ship Building Co.....Port Huron, Mich.

WINCHES.
American Ship Windlass Co.....Providence, R. I.
Hyde Windlass Co.....Bath, Me.

WOOD WORKING MACHINERY.
Atlantic Works, Inc.....Philadelphia.

WRECKING AND SALVAGE COMPANIES.
Donnelly Salvage & Wrecking Co.....Kingston, Ont.
Midland Towing & Wrecking Co., Ltd.....Midland, Ont.
Swain Wrecking Co.....Detroit.

YACHT SAILS, FITTINGS, HARDWARE, ETC.
Wilson & Silsby.....Boston.

YACHT AND BOAT BUILDERS.
Drein, Thos. & Son.....Wilmington, Del.
Gas Engine & Power Co.....New York.
Lane & DeGroot.....Brooklyn.
Willard, Chas. P. & Co.....Chicago.

YAWLS.
Drein, Thos. & Son.....Wilmington, Del.
Lane & DeGroot.....Brooklyn.

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No. 18,	Southwestern Limited	.....	*1 55 am
No. 22,	Lake Shore Limited	*2 15 am	*2 20 am
No. 26,	Chicago & Cleveland Express	*7 30 am	.....
No. 28,	New York & Boston Express	*7 40 am	*8 00 am
No. 40,	Toledo & Buffalo Accom.	†10 00 am	†11 40 am
No. 32,	Fast Mail	*11 25 am	*11 30 am
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No. 40,	Toledo & Buffalo Accom., via Norwalk	†10 00 am	†11 40 am
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	Westward:—	Ar. fr. East.	Dep. West.
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No. 133,	Cleveland & Detroit Express	.....	*12 45 pm
No. 47,	Accommodation	.....	†3 00 pm
No. 141,	Sandusky Accommodation	.....	†3 10 pm
No. 127,	Norwalk Accommodation	.....	†5 10 pm
No. 37,	Pacific Express	*7 00 pm	*7 20 pm
No. 25,	Southern Express	*9 30 pm	.....
No. 3,	Fast Mail Limited	*10 50 pm	*10 55 pm
No. 115,	Conneaut Accommodation	†8 30 am	.....

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*Galion and intermediate	6 00 am	9 25 pm
*St. Louis Ltd., Indianapolis, Columbus, Cincinnati	8 00 am	10 25 pm
*Columbus, Springfield, Dayton, Indianapolis, Cin	12 35 pm	2 55 pm
*Indianapolis & St. Louis	1 30 pm	2 30 pm
Galion to Cleveland	.....	9 00 am
To Galion and Columbus	4 00 pm	.....
*Columbus, Springfield, Dayton, Cincinnati	9 30 pm	6 45 am

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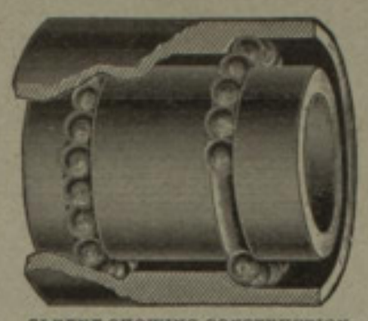

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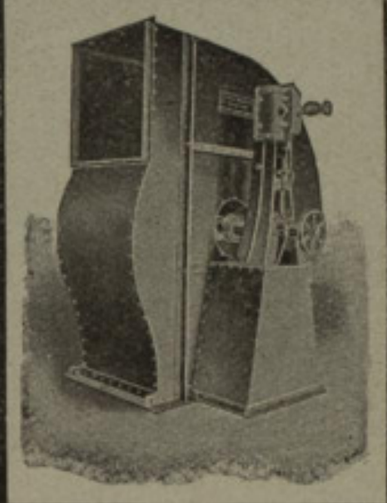

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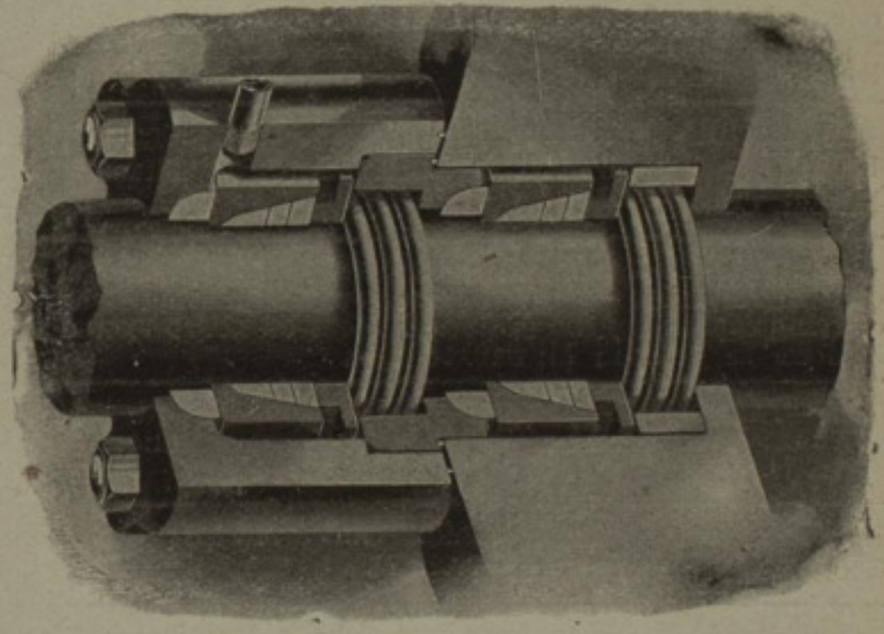

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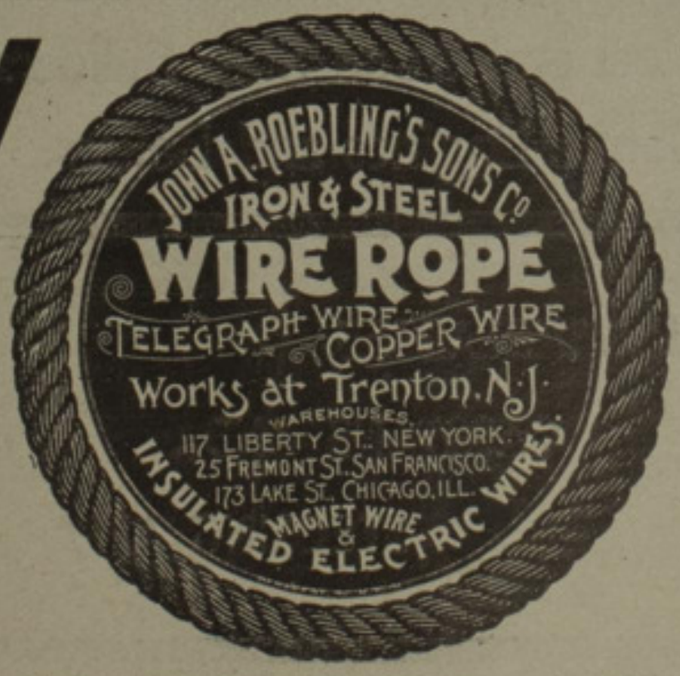

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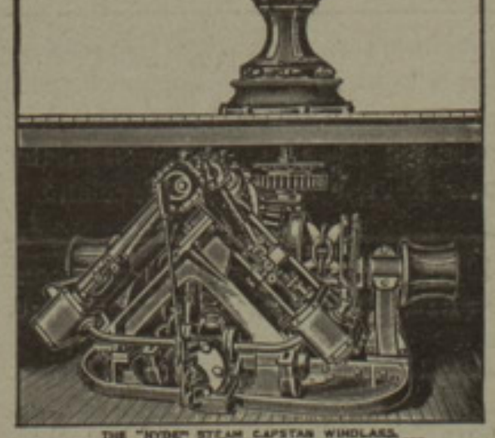

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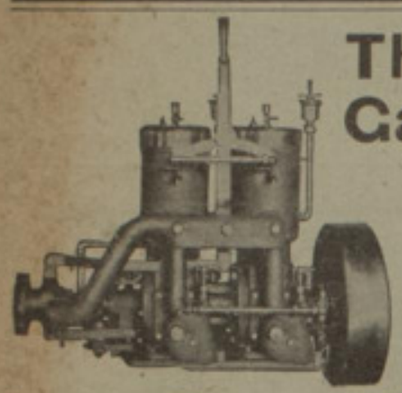

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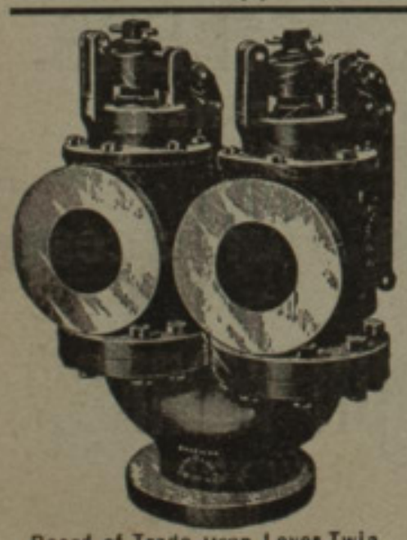

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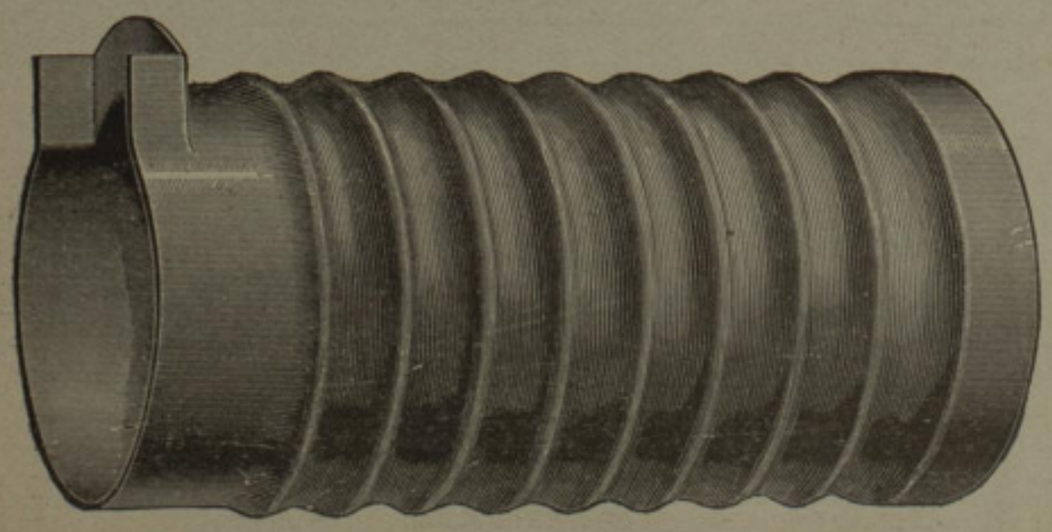

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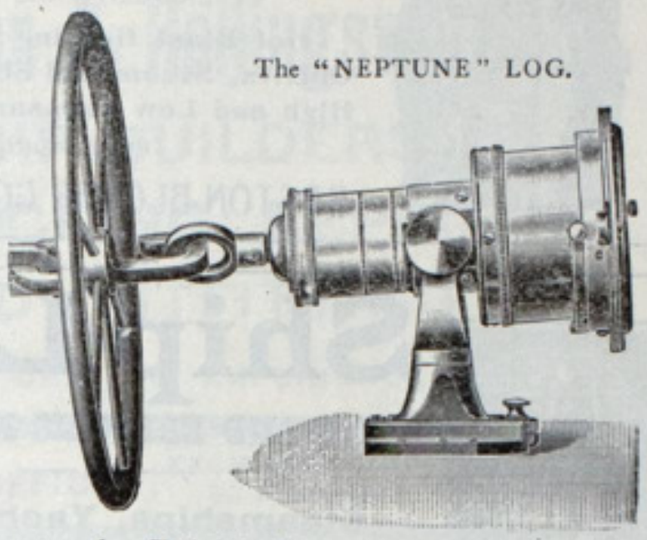

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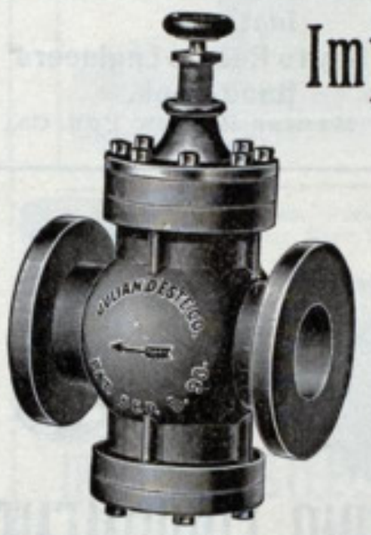

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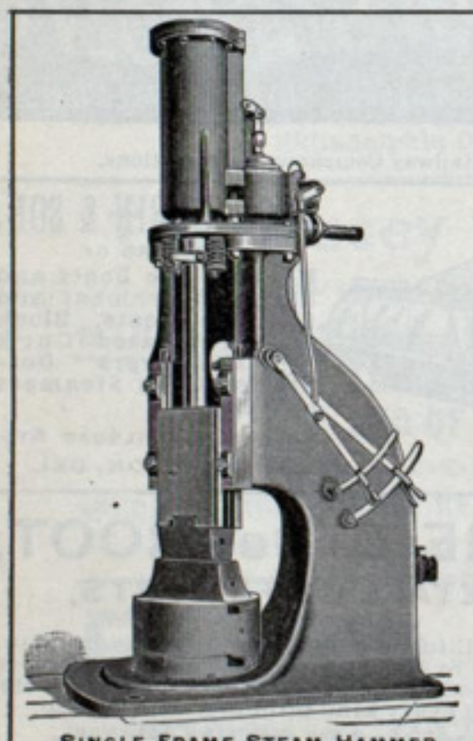

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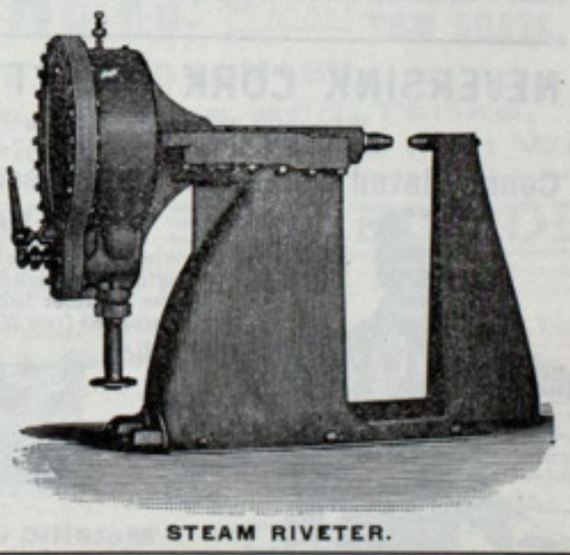

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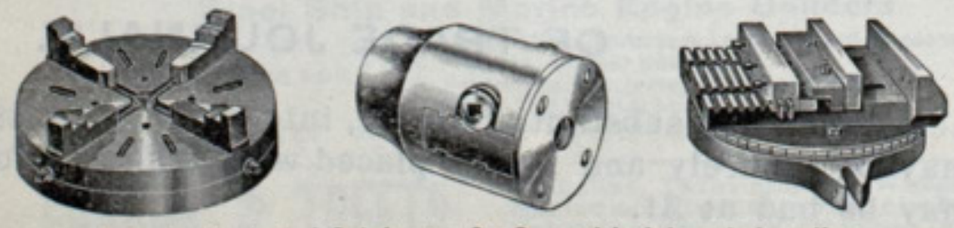

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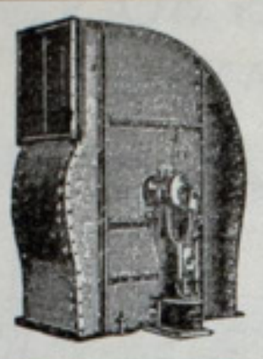

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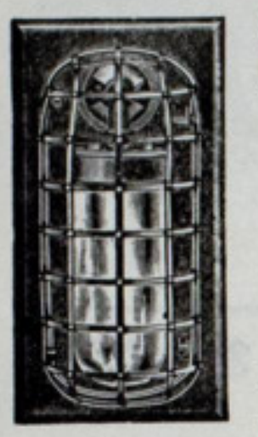

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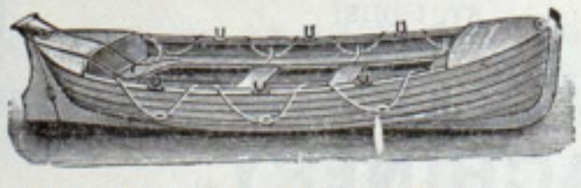

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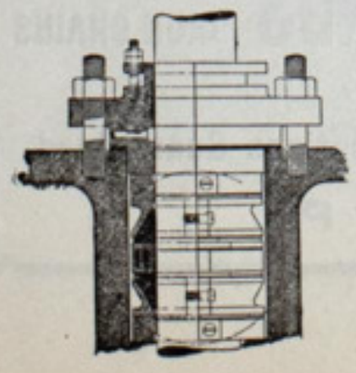

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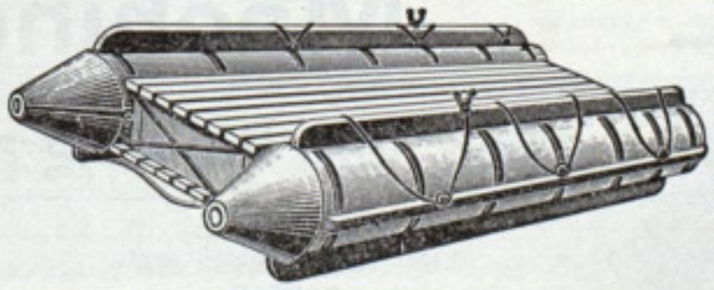

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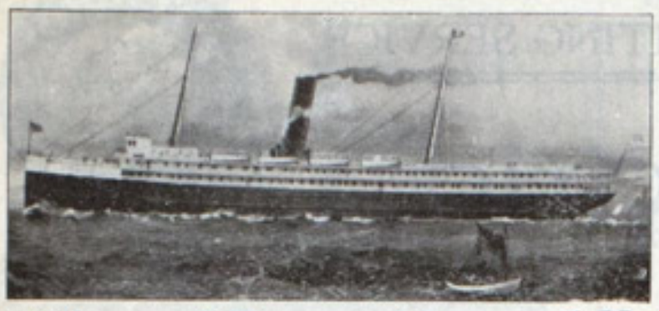

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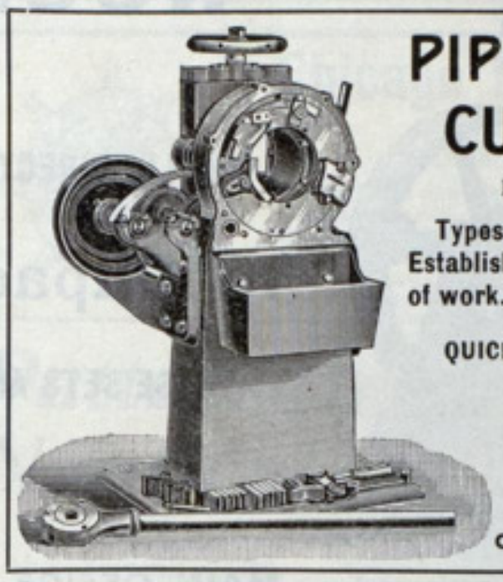

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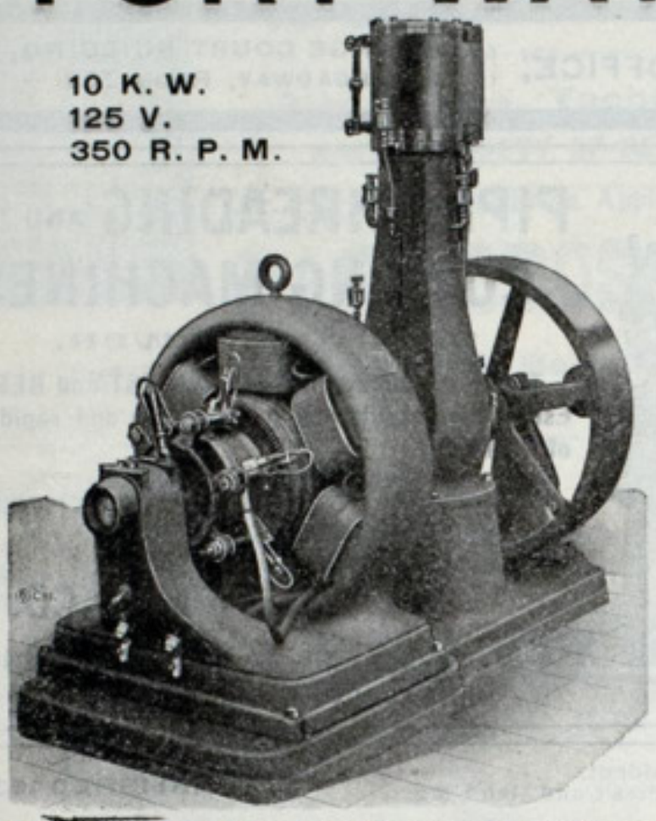

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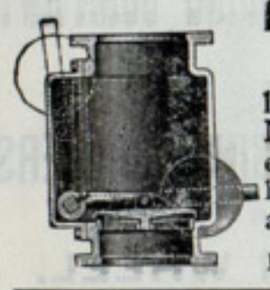

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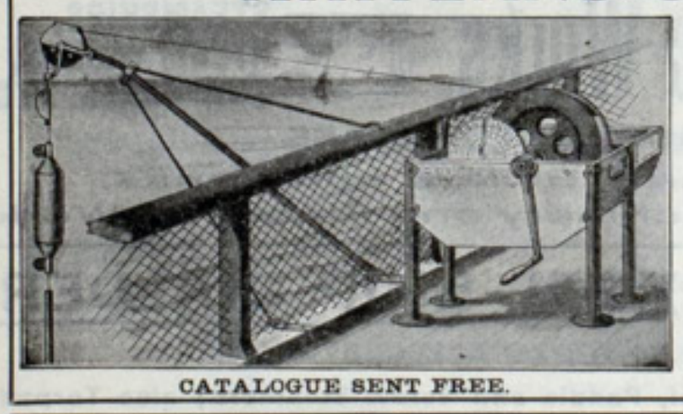

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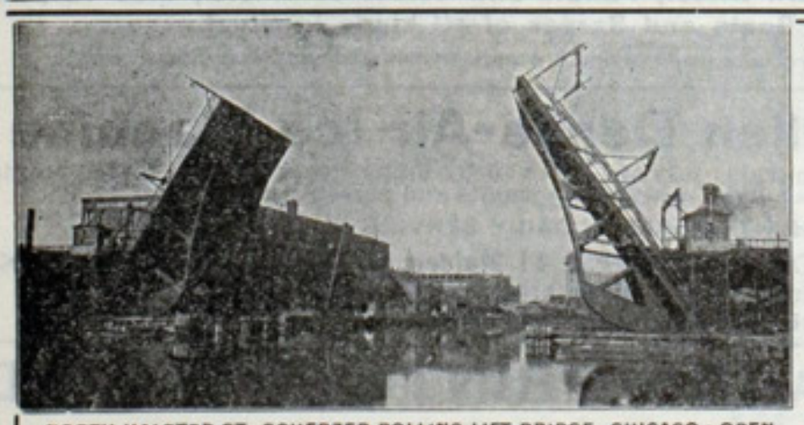

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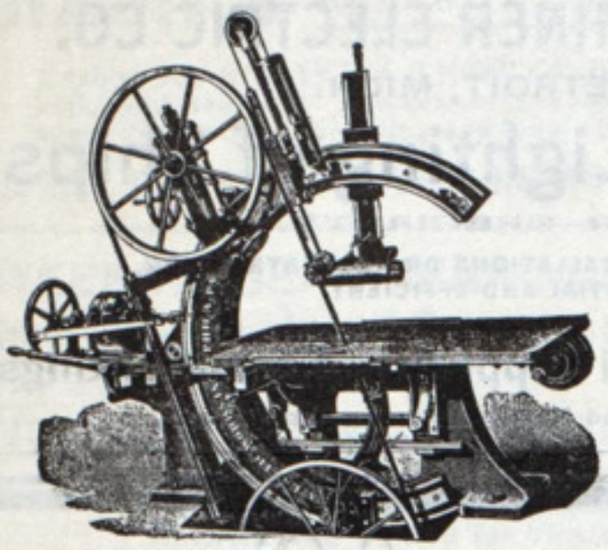

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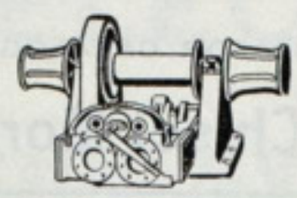

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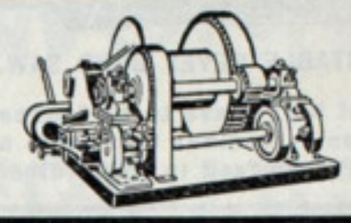

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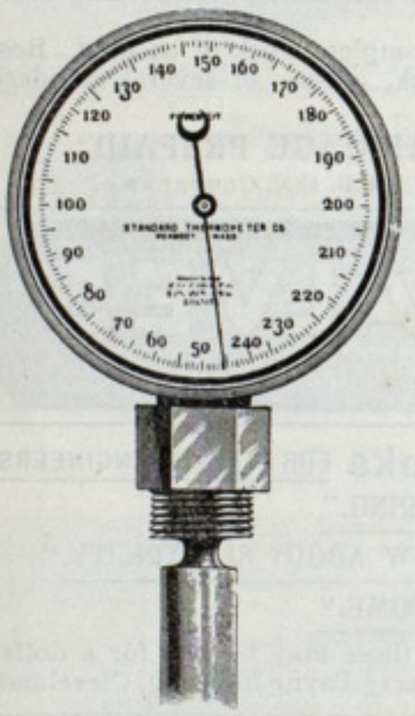

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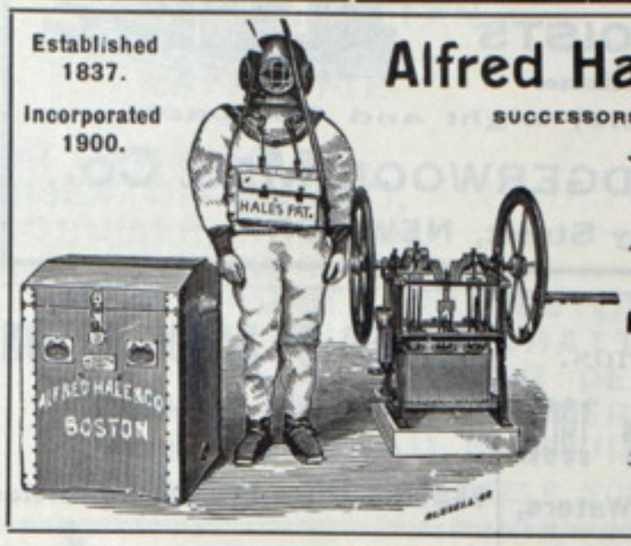

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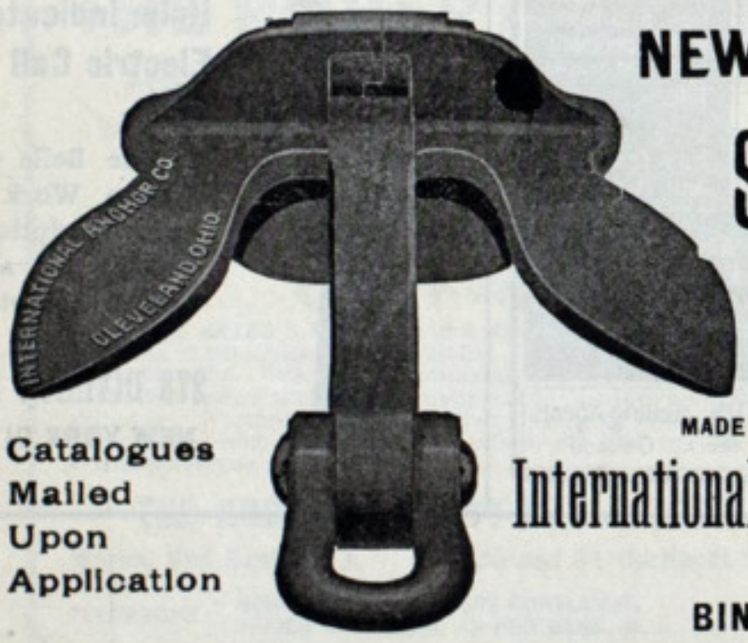

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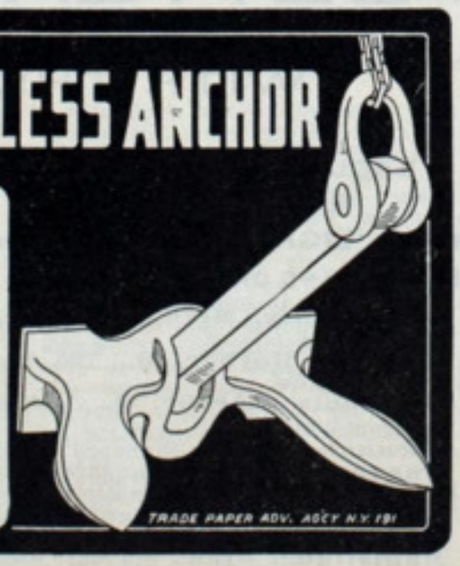

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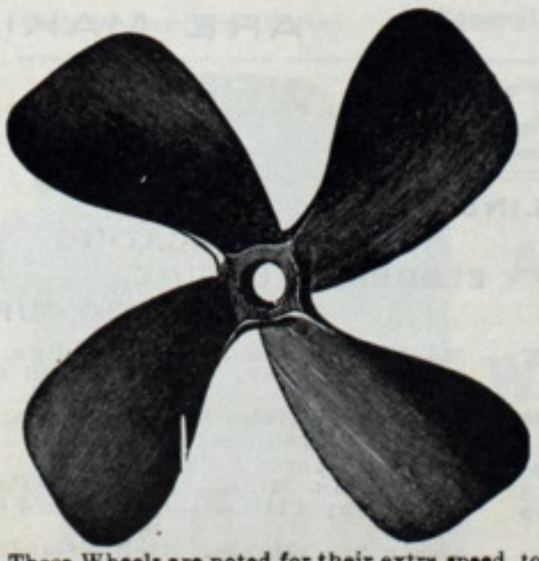

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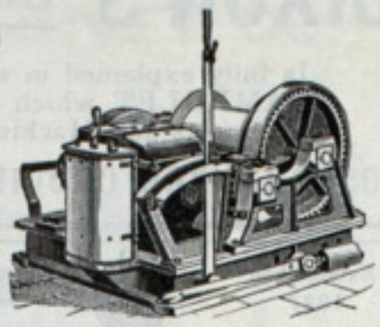

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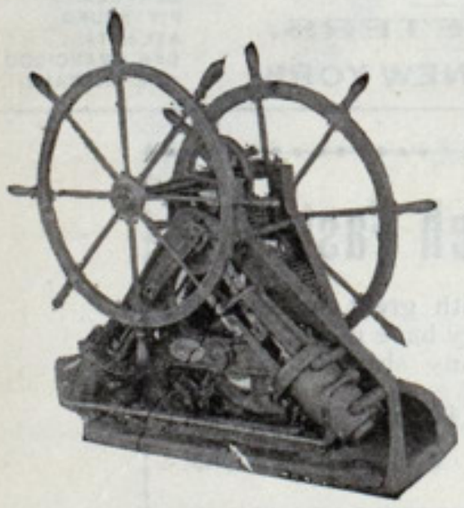

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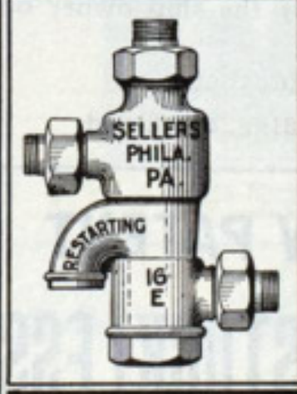

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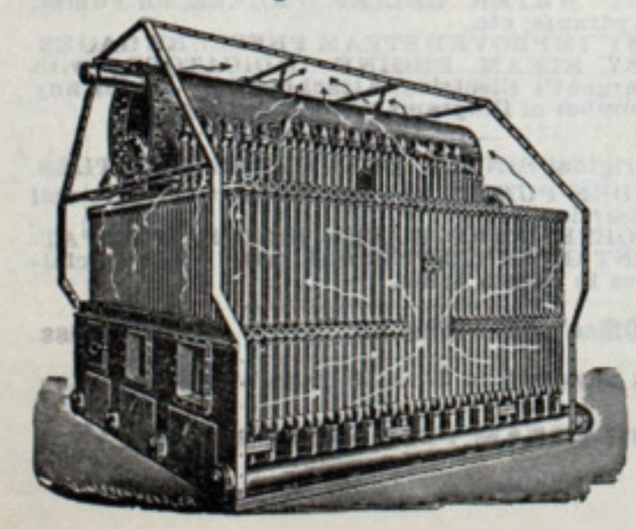

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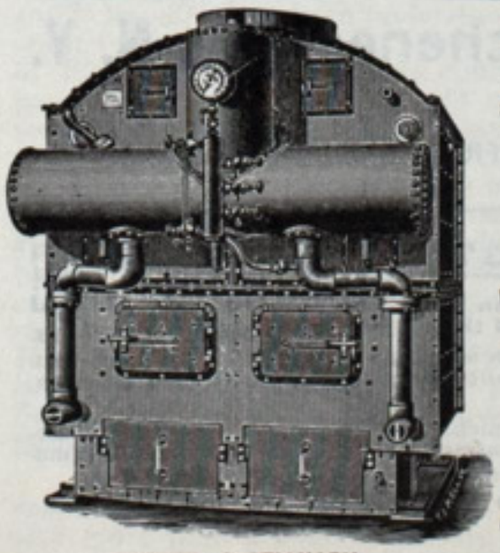

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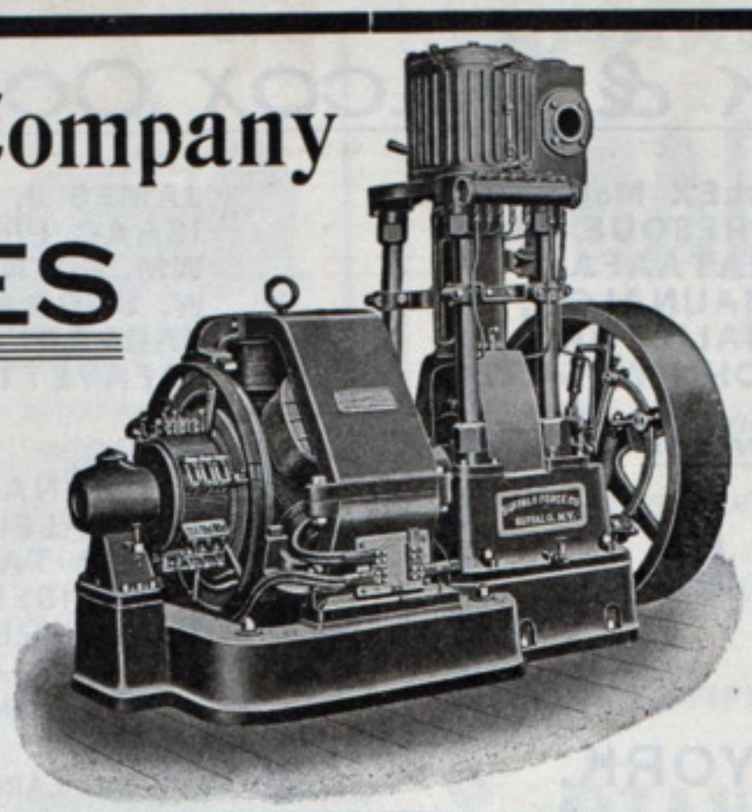

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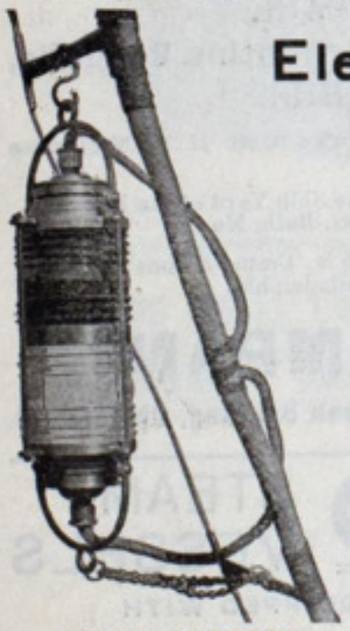

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